SERVICE-LEARNING IN AN INTRODUCTORY ENVIRONMENTAL SCIENCE COURSE: HOW PARTICIPATION IMPACTS COURSE CONTENT KNOWLEDGE AND AGENCY

by

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DEDICATION

I dedicate this to my family for supporting and encouraging me along the way. To my husband Brian, daughter Hadley, son Owen, and little dog Smokey.

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ABSTRACT

Service-learning (SL) is a high-impact pedagogical strategy that has been shown to have both cognitive and affective benefits for students and has the potential to engage and involve a more demographically diverse spectrum of students into the field of STEM. However, research on the impacts of SL in STEM courses is limited, and therefore there is a great need to identify the specific outcomes linked to participation. In addition, faculty from STEM fields have been hesitant to incorporate SL into their curriculum due to perceptions that it lacks academic rigor. This purpose of this mixed-methods case study was to examine how participation in SL in an introductory environmental science course specifically impacted students' knowledge of course content and development of agency, both at the projects and beyond. Students in the study participated in a range of different SL projects through the course. SL outcomes were compared across different types of SL projects to determine the overall impact of SL on course content and agency growth, as well as to more effectively assess the general characteristics of projects that fostered growth in these areas. The findings from this study showed that SL participation led to increases in both course content knowledge and agency. Students with high course content knowledge growth also had exhibited high agency in the projects. The findings did not, however, show any significant differences in course content growth and agency across projects. This is likely due to the fact that all the SL projects in the study were well established and already using best practices in their projects. The results of this study

contribute additional research on SL impacts in STEM to the field and also help guide best practices for the future.

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LIST OF ABBREVIATIONS

SL	Service-Learning
STEM	Science, Technology, Engineering, and Math
EBIP	Evidence-Based Instructional Practice
FG	First-Generation
ELT	Experiential Learning Theory
EL	Experiential Learning
LIFG	Low-Income First Generation
PBL	Problem-Based Learning
RSL	Research Service-Learning
AAAS	Advancement of American Science
HBCU	Historically Black College/University
SALG	Student Assessment of Learning Goals
NEP	New Ecological Paradigm
NGSS	Next Generation Science Standards
CSA	Critical Science Agency

CHAPTER 1: INTRODUCTION

Introduction

Service learning (SL) is defined as "a teaching and learning strategy that integrates meaningful community service with instruction and reflection, provides students opportunities to apply knowledge in practical situations, and develops skills from the experience of connecting theory with practice" (Hamerlinck, 2013). It was first introduced in the 1970s as a tool to provide students with opportunities to bridge theory with practice through hands-on experiential learning, while simultaneously addressing community needs and promoting civic engagement (Waldner, McGorry & Widener, 2012). Rooted in the theoretical ideas about learning, and experience presented by John Dewey in the early part of the century (Dewey, 1938), there is significant research on the perceived benefits SL presents to students.

Since the 1990s, there has been a substantial body of published research studies documenting the benefits of SL to students. These include improved academic performance and achievement of learning outcomes (Astin & Sax, 1998; Eyler & Giles, 1999; Kendrick, 1996, McKenna & Rizzo, 2008; Strage, 2000), development of self-efficacy and personal growth (Astin & Sax, 1998; Eyler & Giles, 1999; Kendrick, 1996; McKenna & Rizzo, 2008), development of social/environmental responsibility and citizenship skills (Astin & Sax, 1998; Eyler & Giles, 1999; McKenna & Rizzo, 2008; Packer, 2009) and development of life skills/career development (Astin & Sax, 1998; Kendrick, 1996). Because of these perceived benefits and SL's unique ability to foster both cognitive and affective growth within students, it has been identified as a high impact pedagogical practice and is now widely incorporated into university courses in a wide range of disciplines (Daniels et al., 2015). Up to 68 percent of current colleges and universities now incorporate some type of community service into their curriculum (Bernot et al., 2018).

Although SL is now widely institutionalized into colleges and universities throughout the US, its role in STEM courses has only recently begun to expand. In 2010, the Corporation for National and Community Service's Learn and Serve America program awarded 13 grants to higher education and K-12 institutions to support the development and integration of innovative SL programming in STEM education, which included several college and university SL programs (Hamerlinck, 2013). This emphasis was largely motivated by a growing need for STEM professionals in the workforce, which is predicted to result in a shortage of up to 2.4 million workers by 2018. Remaining competitive in the global economy is essential to the US given that STEM occupations are projected to grow by as much as 17 percent by 2018, compared to only a 9.8 percent growth rate for non-STEM professions (Langdon et al., 2011). In order to increase both preparation for and interest in STEM in higher education, "fresh approaches to STEM education are necessary in order to address the disconnect in workforce development" (Hamerlinck, 2013). This is essential given that both interest in STEM and preparation for college science and math are declining, with only 45 percent of 2011 U.S. high school graduates prepared for college-level math and 30 percent adequately prepared for college-level science courses (Chen, 2013).

Attrition rates from students enrolled in college STEM programs are also a major impetus for innovation in STEM education, given that only 38 percent of students who start with a STEM major complete their degree in this field (Chen, 2013). This is particularly low among women and underrepresented students.

A decline in interest and knowledge in science is another major challenge facing the U.S. According to a national survey by the California Academy of Sciences in 2001, only 35 percent of college graduates could correctly answer three basic science questions (compared with twenty percent of the general population) (Cramer, 2001). This is concerning in a time when science-related issues (global climate change, genetic engineering, energy resources, extinction rates, cloning, pollution and technology /innovation) are increasingly intersecting with daily life. Given the growing need for an educated workforce and the pressing need for the public to understand scientific issues that affect daily life, there is great need to promote innovative education in the STEM fields. This is critical to both the economy and our democracy. Finding ways to spark interest in STEM and to more effectively educate our citizens is critical to the success of our nation.

SL, when applied to STEM curricula in higher education, has the unique potential to increase interest, motivation, and persistence for students. Research has shown that SL provides opportunities to apply content knowledge to practical situations, develop problem solving and critical thinking skills, and develop professional skills that connect theory to practice, all outcomes that could help retain students in STEM fields (Eyler & Giles, 1999). Moreover, according to Hamerlinck (2013), “a recent survey by Intel and Change the Equation…. found that teenagers’ interest in pursuing engineering increases dramatically when they hear about the ways it might benefit the world.” In addition to skill development, SL STEM also provides students opportunities to experience how STEM skills and knowledge can benefit their communities and are relevant to their own lives.

Statement of Purpose

Although there is a substantial body of research on the skills and values attained through SL in general, very little research has been conducted to date on its application to STEM courses specifically, particularly in introductory-level courses. Historically, college teaching in STEM courses has emphasized traditional lectures that focus on course content, but in recent years, there has been a shift towards the integration of more active teaching strategies such as SL in order to increase student enrollment and diversity in STEM due to high attrition rates, and meet the increasing demand for STEM professionals in the future (Daniels et al., 2015). With this shift, there is also a need for research that assesses the impacts of active learning strategies upon students.

The primary purpose of this mixed-methods case study was to more adequately assess the outcomes that were linked with participation in a STEM SL projects in a higher education environmental science course. The goal of this study was to gain further insight into the role that SL curricula can play in STEM courses and to help identify best practices moving forward. It is hope that the study would contribute to the increasing body of literature in the field and help practitioners and researchers alike consider ways in which SL STEM can encourage greater access to and interest in STEM, foster scientific literacy, and encourage persistence in STEM courses. More specifically, this research used a case study model that assessed student outcomes (course content knowledge and agency) in SL projects and drew general conclusions about the what types of SL projects were most effective at fostering these outcomes.

In this study, students enrolled in an introductory environmental science course at a mid-sized urban university participated in different SL projects that were well-integrated with course content, aligned with course learning goals, and incorporated critical reflection and analysis throughout the process. The primary goal of integrating SL into the course was to provide hands-on opportunities for students to connect abstract course concepts to real-life contexts. In addition, because the course had a diverse variety of student majors with a range of experiences in science, the instructor believed that SL was a unique pedagogical tool that could meet a breadth of student needs in one setting. Students in the course self-selected an SL project based-upon their individual interests and schedules, and project partners had the flexibility to assign tasks based upon student interest and experience levels. This adaptability created a differentiated learning environment that was not easily replicated in a large classroom environment. In addition, the instructor believed that SL participation provided opportunities for career exposure, provided opportunities for students with limited prior knowledge to feel successful in science, built upon individual students' funds of knowledge, and increased scientific literacy by providing students with exposure to complex scientific problems in relevant contexts.

Although the course had integrated SL for a number of years and both the SL projects and curriculum were well-defined, it was difficult for the instructor to assess specifically what students were gaining from their SL experiences, especially given the diverse range of students who took the course and the breadth of SL projects that students were engaged in. Five years of prior data from the university's SL program evaluations indicated that students in the course enjoyed and benefitted from their SL experience (Mike Stefancic, personal communication, October, 2016). However, the instructor had limited knowledge of how SL participation specifically impacted uptake and application of course content knowledge (course content knowledge) and how it might also impact how their attitudes towards science and their capacity to make a difference in the issues they were addressing in their projects in the future (agency). In addition, it was difficult to assess if these outcomes differed depending upon the type of SL project that the students were engaged in. The course curriculum and learning objectives for the SL projects remained stagnant, however the types of project that students were engaged in differed in both topic and project activities, so it was unclear how much the specific projects influenced uptake of course content knowledge and development of agency.

Using both qualitative and quantitative methods, this mixed-methods case study formally and informally assessed what that students took away from their SL experience, with a specific focus on course content knowledge and development of agency, which was defined as capacity to affect change and to take action in social context (Bandura, 2000). A secondary goal of the study was to analyze how these impacts vary depending upon the type and scope of project. Comparing the learning outcomes from different types of SL projects could inform future instruction and project design of SL STEM curricula. It also helped provide insight into the general characteristics of projects that were the most effective at contributing to these student outcomes. More specifically, assessing the outcomes of SL in a large, introductory course gave insight to guide best practices for future courses with consideration of the how best to structure service experiences to meet the needs of a diverse range of students in a large course.

Research Questions

There were two primary research questions that guided this mixed-methods case study that explored the implications of student outcomes from SL participation in an environmental science course. The research questions were as follows:

1. How does participation in service-learning, in an introductory environmental science course, impact course content knowledge and agency?
    a. What, if any, is the correlation between course content knowledge and agency development?
2. How do course content knowledge and agency development differ across service-learning sites?

The goal of the first question was to gain more insight into the specific outcomes that students gain from participation in diverse SL projects in a large, introductory-level environmental science course. It was hypothesized that if SL provided opportunities for students to connect abstract concepts to concrete experiences and SL was well-aligned with course learning objectives, then student content knowledge would increase. Moreover, because students were engaged in self-selected hands-on projects in social contexts where they played an active role in addressing environmental problems, it was hypothesized that student agency would increase as well. The goal of the second question was to assess the differences and similarities across SL sites in terms of content knowledge and agency development. For example, did a student who was engaged in a project related to biodiversity and invasive species have higher increases in content knowledge in these areas? Did interaction with the community partner and type of project tasks impact agency? The purpose of this research question was to gain insight into which type/scope of SL projects resulted in the greatest growth in content knowledge and agency development. This could guide best practices for future SL STEM projects.

Significance of the Study

Though many articles have been written over the past 20 years that highlight the general skills and attributes gained through participation in service learning, the body of literature on STEM-specific courses is quite minimal, particularly with regard to introductory-level courses. However, despite limited literature in this field, there is growing interest in cultivating and expanding SL STEM education, with recent grants by the Corporation for National Service specifically targeting SL STEM development and innovation in higher education. Program summaries from the grantees have highlighted the benefits experienced by both students and faculty that engaged in SL STEM projects. The Florida Campus Compact program, for example, found an 86 percent increase in interest in STEM disciplines. Washington Campus Compact found that 72 percent of students felt SL enhanced understanding of scientific course concepts (Hamerlinck, 2013).

Because of the limited literature in the field to date, coupled with growth in this area of SL, there is a great need for empirical studies that identify the unique benefits of SL to STEM courses, assess specific student outcomes from participation, and identify best practices with regard to project design and implementation. According to Hayford, Blomstrom, and Mumpower (2015) who conducted a literature review of SL STEM, current literature is lacking rigorous research design. Although most SL studies in

Biology and environmental science took place in large-enrollment, non-major courses, the SL component was not well integrated and was limited in scope (three to six hours in total) (Cawthorn et al., 2011; Leege & Cawthorn, 2008; Packer, 2009; Brubaker & Ostroff, 2000; Ng & Ling Ling, 2012). Because many of these projects were limited in time frame, it is difficult to assess whether the findings were attributed to service participation or to other variables such as instructor quality, class demographics, quality of reflection exercises, etc.

One of the most critical questions that has emerged from current literature is how SL projects can be designed and implemented so that content knowledge is enhanced rather than compromised. This is also one of the major concerns expressed by STEM faculty who consider adopting SL and one area of current literature where SL benefits have been mixed (Brubaker & Ostroff, 2000). More recent literature in SL STEM has focused upon specific pedagogical practices that enhance the academic outcomes of SL STEM, for example integrating research, inquiry, or problem-based learning (PBL) with the SL projects (Daniels et al., 2015; Reynolds & Ahern-Dodson, 2010; Tawfik et al., 2014; Bernot et al. 2018). However, more research is needed to address the influence of the project type and scope upon their effectiveness.

SL to Meet STEM Demands

Another benefit to research in SL STEM is that it has the potential to need to increase innovation in science teaching, which can ultimately help address workforce demands in this field. Given that the U.S. is faced with both a growing demand for a STEM workforce and a decline in interest/preparation in STEM, it is critical that educational strategies that can both increase participation and foster persistence in STEM education are identified. Recruitment of a more demographically diverse range of students to STEM is critical, and retention of these students is perhaps even more pressing. Recent studies have ranked the quality of STEM education in the U.S. as 48th globally (Hamerlinck, 2013). This is reflected in low preparation rates in STEM from high school and high attrition rates from STEM majors in college. To shift the current status of STEM education in the U.S., it is critical that more emphasis is placed upon pedagogical strategies that enhance instruction, better prepare students with the skills they need to succeed in this field, and provide relevant contexts for exploring scientific concepts.

There is growing concern in the U.S. over student achievement with regard to STEM, based on declining test scores by students in science and math on the ACT and standardized tests taken in 8th grade (Hayford and Blostrom, 2014) Statistics have also shown that the U.S. is not adequately prepared to fill these needs, given a declining number of undergraduates majoring in STEM (Fairweather, 2008) and high attrition rates from these majors. More than half of freshmen who declared STEM majors at the start of college left these fields before graduation (Chen, 2013; National Girls Collaborative, 2016).

These concerns have spurred a renewed discussion among policy makers about how to improve scientific literacy and motivate students, particularly for underrepresented students and women, to pursue careers in STEM. The highest rates of attrition are from women and underrepresented students (National Science Board, 2018) particularly in engineering, computer science, and physical science (National Girls Collaborative, 2017).

While there a are range of social and cultural factors linked to the attrition from STEM, pedagogical practice has been identified as one of the primary influences in attrition rates and there has been a push to re-think STEM teaching pedagogy as a result (Hayford, et al., 2014; Alberts, 2013; Sithole et al., 2017).

> The scant connection between curricula and career needs in STEM programs makes [STEM] disciplines less attractive than other programs. In particular, in STEM there is more protracted emphasis on academic mastery of concepts than career applications and relevancy. Developing programs that influence students' attitudes positively towards STEM programs may well increase completion and persistence rates in STEM programs. Some instructors concentrate only on non-pedagogical research and publication, with almost no effort to improve teaching techniques and virtually no attempts to offer initiatives to improve students' interest in the courses. It seems to be taken for granted that students will naturally, somehow by 'osmosis', or mere proximity, develop positive attitudes toward science as they take science classes (Sithole et al., 2017).

Alberts (2013) called for major changes in the way college-level science is taught through incorporating "active science inquiry into all introductory college science courses (p 1)." One strategy for increasing student engagement is the use of "evidenced-based instructional practices" (EBIPs) that engage students in active learning and move away from traditional lectures and scripted labs (Fairweather, 2008). Empirical research has shown that EBIPs are more effective teaching strategies than traditional lecture/discussion and more effectively support student learning by tapping into a student's prior knowledge, increasing motivation, incorporating metacognitive monitoring, and factoring in the social and cultural factors that can impact learning (Ambrose et al., 2010). While there are many types of EBIPs, they are generally defined as both “strategies that can be used within existing course structures” such as think-pair-share or clicker questions, or “systems that drive designs of entire courses” for example Problem Based Learning (PBL) or Process Oriented Guided Inquiry Learning (POGIL). (Boise State CTL, 2018). SL in particular has been identified as one type of EBIP.

SL to Foster STEM Equity

As an EBIP, SL has many potential benefits that could potentially improve STEM pedagogy, as well as help develop specific professional and research skills students need to be successful in STEM careers. Given that attrition rates in STEM are highest among underrepresented students and women, and the tremendous need to expand and diversify the workforce in STEM, it is critical that SL STEM programs are designed with the consideration of the needs of underrepresented students and women.

Colleges and universities in the United States are becoming increasingly diverse, with historic numbers of students from traditionally underrepresented groups now entering college. Many of these students face tremendous obstacles to completing a college degree. First generation students (FG), whose parents have not obtained a four-year college degree, represent up to 50 percent of the current student population. It is estimated that up to 86.8 percent of FG students are minorities. These students are particularly vulnerable to leaving college, with a 15 percent lower persistence rate than their non-FG peers and 50 percent higher drop-out rate after their first year of college (Pelco et al., 2015). FG and particularly low-income FG (LIFG) students face challenges in college such as not being academically prepared for the rigor of higher education, being unfamiliar with the academic culture of college (lacking cultural capital), and lacking academic self-efficacy (Kuh, 2008).

One strategy for supporting underrepresented students that has been shown to be effective is the incorporation of high impact teaching practices/EBIPs into classrooms such as SL, collaborative assignments, internships, and learning communities (Kuh, 2008). SL in particular has been shown to have benefits for underrepresented students and has the potential to increase equity and access in higher education, particularly in the STEM fields. Current literature on the benefits of SL to underrepresented students, although limited, has shown that SL positively contributes to student growth in several areas including social and cultural capital (Yeh, 2010); student agency (Yeh, 2010; Daniels et al., 2015); critical thinking, problem solving, and critical consciousness (Yeh, 2010; York, 2016); and academic skills such as communication, writing, leadership development, and critical thinking (Yeh, 2010; Daniels et al., 2015; York, 2016; Pelco et al., 2015). If designed well, SL STEM projects can provide unique opportunities to more actively engage underrepresented students and women in STEM, which could translate into meeting future workforce demands.

SL to Promote Science Literacy

SL STEM also provides an opportunity to increase scientific literacy in the U.S. Although interest in STEM is on the rise due in part to national efforts to increase the number and diversity of students pursuing degrees and careers in STEM fields (Chen, 2013), student interest in majoring in STEM still lags behind global competitors, with the U.S. having one of the lowest ratios of STEM to non-STEM majors in higher education in the world (Chen, 2013).

Encouraging more interest and understanding of scientific principles among the general public is critical to both the future workforce and to our democracy. According to a national survey developed by the California Academy of Sciences (CAS) in 2001, the American public lacks basic scientific knowledge even as science increasingly intersects with our daily lives. The national survey indicated that 43 percent of Americans do not have a solid understanding of what scientists are doing to address key issues (Cramer, 2001). Without understanding of key scientific issues and the concepts that ground them, the public is unprepared to make informed decisions.

One major factor that has contributed to declining knowledge and interest in science decline is the status of STEM education in the U.S. According to a report by Pew Research (2015), Americans and members of American Association for the Advancement of Science (AAAS) both believe the U.S. K-12 education in STEM is “average” or “below average” in comparison with other industrialized countries (Cramer, 2001). Members of the AAAS attribute this lack of basic scientific knowledge with having too little exposure to STEM education in K-12 (Funk & Goo, 2015).

Although the majority of Americans lack understanding of scientific issues, research has also shown that the majority of the public is interested in learning more, particularly with regard to environmental issues, energy resources, and innovation. Survey respondents linked scientific understanding with the ability to more effectively participate in the democratic process, make more informed choices with regard to their health and well-being, and make more informed choice as consumers (Funk & Goo, 2015).

> Not only is science changing dramatically, the challenges we face in our world are changing as well. We are confronted with critical decisions on how to balance the needs of the environment with the need for continuing economic growth and prosperity, and how to meet the increasing need for reliable energy while protecting the nation's air, water, and land (Patrick Kociolek, Curator and Executive Director of the California Academy of Sciences in Cramer, 2001).

It is essential for the public to have a basic grounding in science in order to be able to make informed decisions and participate in discourse on these issues, both critical to the democratic process. Improving the quality of STEM education to improve scientific literacy in the U.S is not only important to the U.S. economy, but also builds a sense of agency within citizens that enables them to more effectively make decisions and feel like they have a role in the democratic process with regard to scientific issues.

SL STEM, specifically, provides an avenue for students to engage and play a role in science issues that affect their local communities. Students gain content knowledge about science and also learn what their role is in addressing local issues. SL STEM has the unique ability to build both citizenship and scientific knowledge.

<u>Best Practices in SL STEM</u>

Clearly there is a strong case for expanding SL into STEM (SL STEM) programs in higher education to improve the quality and relevancy of STEM education in the U.S. The 2010 grant cycle by the Corporation for National Service targeted SL STEM as one of three key academic priorities for innovation in SL. Program summaries from the 13 grantees found that integration of SL STEM was well-received and resulted in significant impacts for both students and faculty (Hamerlinck, 2013). Several recently published articles on SL STEM have also noted positive growth in many key SL skill areas such as civic responsibility, problem solving skills, and science literacy (Hayford et al. 2014; Ng & Ling Ling, 2012; Packer, 2009; Cawthorn et al., 2011; Felzien and Salem, 2008). Content knowledge has continued to be the area with the most minimal gains and has been identified as one of the primary reasons STEM faculty have been hesitant to adopt SL (Brubaker & Ostroff, 2000). More recent literature in the field has emphasized that outcomes in course content growth in STEM can be greatly enhanced when attention is paid to pedagogical design, for example aligning SL with more comprehensive and inquiry-based instruction such as PBL and research-based SL (Bernot et al., 2018; Daniels et al. 2015; Reynolds, 2010; Tawfik et al., 2014)

Current literature has yet to assess the idea of agency development in SL, although a few articles have assessed SL's link to self-efficacy, personal development, and citizenship. No literature to date has specifically emphasized student agency during SL and the role that it can plays in the learning process.

Moreover, current literature has placed less emphasis on the impacts of the type and scope of projects that students are engaged and how this might relate to student outcomes. In the environmental studies course that was the emphasis of this study, the researcher used a design-based learning environment in which SL assignments were well-aligned to course learning objectives and were inquiry-based in design, with critical reflection activities incorporated throughout. Though the pedagogy was consistent for all students, the projects differed with regard to learning activities, level of Bloom's taxonomy required to complete project tasks, and level of partner interaction with students at the project site. Because of this, student outcomes in course content and agency varied quite greatly in past semesters of the class. Social and cultural factors, such as student motivation, cultural background, prior knowledge, and outside of school obligations could have played a role in outcomes. However, anecdotal observations of SL projects over the years has shown that student level of growth in content and agency was largely influenced by the quality of the project experience.

Because project type and scope has not been well assessed in current literature, one of the primary rationales for this study was to be able to draw some general conclusions not only about what students were gaining from SL projects, but also how these differed across SL sites. This data will not only help guide best practices in the rapidly expanding field of SL STEM, but is also invaluable to make STEM courses more engaging and relevant and encourage students from breadth of demographic backgrounds to become interested in and pursue STEM courses in the future.

The chapters that follow explore the significance of this study in further depth. Chapter two begins with an overview of the theoretical framework that guided this study, and also provides a comprehensive review of literature on outcomes from participation in SL, an overview of current SL STEM research, and an overview of current literature relating to agency development in both STEM and SL. Chapter three provides a detailed overview of the methodology for the study, including the data collection and analysis process. Chapter four provides the findings from data collection and analyses. Chapter five provides a short summary of the findings followed by a discussion of the results. The chapter then addresses study limitations, final conclusions, and implications and recommendations for the future.

CHAPTER 2: LITERATURE REVIEW

Theoretical Framework

The theoretical framework that grounds this research is the Experiential Learning Theory (ELT) developed by Psychologist David Kolb in 1984 (Kolb, 2015). ELT is largely based upon the theoretical ideas of John Dewey (1938) who advocated that learning is an extension of life and believed that all experience translates into knowledge (Kolb, 2015; Dewey, 1938). Dewey's ideas are the foundation of experiential learning (EL), or learning through experience, (Kliebard, 2004), which Dewey believed was a continuous process that involved the iteration between thought and experience. Kolb's theory is built upon the theoretical foundations of EL and creates a systematic, practical learning model (ELT) that connects theory with hands-on practice.

ELT also draws many of its core principles from constructivism. Based on the ideas of Jean Piaget (1969), constructivism is a learning theory that asserts that humans make meaning through experience and reflection of these experiences, drawing from prior knowledge to construct new knowledge (Kanuka & Anderson, 1999). More specifically, ELT is based upon social constructivism, a form of constructivism that is based upon the idea that knowledge construction is a social process that is influenced by socio-linguistics (Vygotsky, 1962), environmental and cultural factors (Kanuka & Anderson, 1999) and multiple realities (Jonassen, 1996). Through conversational language, humans negotiate meaning that results in shared knowledge and understanding (Guthrie & McCracken, 2011). When applied to education settings, social constructivists argue that since no two learners will come from the same backgrounds or interpret knowledge in the same way, that a range of experiences that are both meaningful and authentic should be offered to the learner to foster new knowledge. Kanuka and Anderson (1999) offer a variety of pedagogical strategies to facilitate this process, for example use of argumentation, reflection, small group discussions, debriefing, and service-learning. They also call for incorporating learning activities that have real world relevance for each learner and build upon student's prior knowledge. In Kolb's ELT model, reflection and abstract conceptualization play key roles in the process of how concrete experience is translated into reliable knowledge (Kolb, 2015).

SL is a specific form of experiential education that has its theoretical roots in social constructivism and is based upon the ELT model. Community service serves as the context for concrete, real life experiences in which students engage with the local community in social contexts to address community needs. Students then critically reflect upon these experiences and connect/apply them to their own lives and goals (Morton & Troppe, 1996).

In Kolb's ELT model, learning is experienced through a four-step cycle that includes both concrete experiences and abstract reflection of those experiences:

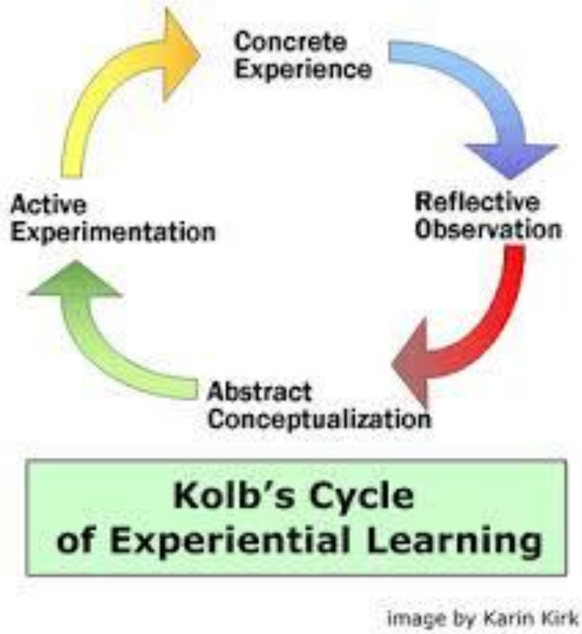

Figure 2.1 Kolb's Model of Experiential Learning (1984) (adapted from Kirk & Thomas, 2003)

Translating the ELT model to SL experiences more specifically, the model's four steps include:

1.Concrete Experiences (CE): Hands-on experiences at a service site connected to the course. Students gain skills, knowledge, and values through these hands-on experiences.

2. Reflective Observation (RO): Students translate and reflect upon concrete experiences through both written and oral reflection activities to gain a greater sense of how the experiences are impacting their personal worldview and building upon their personal funds of knowledge. The also identify the challenges and benefits they have experienced and identify any misconceptions they might have encountered.

3. Abstract Conceptualization (AC): In the third step of the cycle, students are asked to apply and relate what they learned in the field to abstract course concepts, for example how planting sagebrush after a wildfire might impact biodiversity and the

carbon cycle. In this stage, SL bridges the gap between concrete experience and theoretical course content, providing an applicable link between theory and practice.

4. Active Experimentation (AE): In the final stage of the model, students apply the knowledge they have gained to make recommendations based on these experience about how best to address the underlying issues in the future (Eyler & Giles, 1999). In this stage, student's might identify possible solutions to address issues and also consider what their role as an individual might be in addressing these issues in the future. Active experimentation not only refers to the specific issues addressed by the service project, but also how it intersects with individual values relating to citizenship and self-efficacy.

ELT is commonly emphasized in SL literature as being pivotal to the learning process.

> Students learn more deeply when they have multiple concrete referents for abstract concepts, and they are more likely to develop the capacity for critical thought if they are challenged both by surprising experiences and by reflective teachers who help them explore these experiences and question their fundamental assumptions about the world (Lynch, 1996).

The questions of "what," "so what," and "now what," are commonly used to guide SL reflection exercises. These can easily be linked to the ELT four-stage cycle. "What?" aligns with concrete experiences, "so what?" with reflective observation and abstract conceptualization, and "now what?" with active experimentation (Eyler, 2002).

ELT is well-aligned with the purpose and research questions for this mixed methods case study because the goal was to not only assess what students gained from participation in terms of content knowledge, but also to assess what they plan to do with this knowledge once they have it.

The first research question in the study asks, "How does participation in SL, in an introductory environmental science course, impact students overall course content knowledge and agency?" This question is referring to outcomes in two areas: content and agency. Course content relates to the ELT cycle with regard to how able are students to connect concrete experiences (part one of the ELT cycle) with abstract course concepts (part three of the cycle).

The second outcome, agency, addresses what students will they do with abstract course content knowledge they gain and are they able to relate it to applied issues from their service experiences? Defined as the capacity to affect change and to take action in social context (Bandura, 2000), student agency development is linked directly to the affective skills gained through SL participation. In this study, this relates to how students view the issue they are addressing in light of participation and reflection in the SL project (part two of the ELT cycle). How does it connect to their level of participation/engagement in the project? How does participation impact student level of engagement in the future? These questions directly relate to abstract conceptualization (part four of the EL cycle) and the SL reflection question of "now what?"

Bandura (2000) directly links agency development to self-efficacy and identity development. In STEM fields, this is critical to recruitment and retention of a more demographically diverse pool of STEM majors. Students may gain content knowledge through SL participation, but how effective is SL at building agency within the larger context of issues they are addressing? Do students feel they have a role in this process?

SL has the unique opportunity to provide students who might not normally have interest or prior knowledge in science to feel that they have a role in addressing scientific issues, which ultimately may encourage them to pursue additional STEM courses or to gain confidence to engage in public discourse or take action around scientific issues.

The second research question in the study asked, “How does course content knowledge and agency development differ across SL sites?” This question addresses the outcomes from different projects and assesses what parts of the ELT cycle may have impacted course content knowledge and agency development. For example, did the learning activities (concrete experiences) foster content knowledge growth? Did on-site dialogue/reflection with the community partner and peers impact agency development (reflective observation)? How effectively were course concepts integrated into the project tasks (abstract conceptualization)? Was the purpose and value of the student participation effectively expressed by the community partner (active experimentation) or were students, for example, left to weed plants without understanding the larger purpose in relation to the agency’s goals of their efforts? All of these factors can impact student outcomes.

Ultimately, the theoretical foundations of the ELT model are rooted in the notion that education is a product of experience and that the most knowledge construction occurs when these experiences are integrated with personal reflection and connection to the larger purpose of what they are doing. It is an iterative process and learning is a continuous construct. SL has the unique ability to not only foster cognitive growth, but also growth in the affective domain. Giving students a place to see the value of and purpose of their education in the field builds a sense of agency and can create more engaged citizens who have interest in the scientific process and confidence in their ability to have a role in this.

Value of Service Learning and Best Practices

Service learning (SL) is a pedagogical practice that provides students with opportunities to bridge theory with practice through hands-on experiential learning, while simultaneously addressing community needs and promoting civic engagement (Waldner, McGorry & Widener 2012). Because of the perceived benefits it presents to students, SL is now widely incorporated into many college classrooms in a wide range of disciplines throughout the country. It is estimated that approximately 40 percent of full-time, 1st-year students will take a course integrated with community service and up to 68 percent of colleges and universities now incorporate SL (Bernot et al., 2018).

A substantial body of literature has documented the benefits of SL and the specific values and skills (outcomes) that it provides to students. These include improved academic performance and achievement of learning outcomes (Astin & Sax, 1998; Eyler & Giles, 1999; Kendrick, 1996, McKenna and Rizzo, 2008; Strage 2000), development of self-efficacy and personal growth (Astin & Sax, 1998; Eyler & Giles, 1999; Kendrick, 1996; McKenna & Rizzo, 2008), development of social/environmental responsibility and citizenship skills (Astin & Sax, 1998; Eyler & Giles, 1999; McKenna & Rizzo, 2008; Packer, 2009) and development of life skills/career development: (Astin & Sax, 1998; Kendrick, 1996).

SL is unique in that it benefits both the affective and cognitive domain. Outcomes from SL are generally grouped into four categories: cognitive, behavioral, emotional, social engagement (Simeon, 2008). In SL, the melding of the cognitive with the affective is an iterative process in which feelings and actions are integrated with abstract concepts and intellectual thought, (Eyler & Giles, 1991, p. 194). This process is holistic, with the four outcomes interacting with one another rather than in isolation. This is illustrated in the ELT cycle as concrete experiences at the service site are blended with personal reflection and dialogue with peers/community partners to enhance learning and help students make meaning of abstract concepts. The unique ability to connect the personal and affective with the intellectual and academic is one reason that SL has been touted as a high impact practice with the ability to engage a wide range of students in a breadth of academic contexts. This case study, for example, looked at the interactions of the cognitive and affective domains by assessing the impacts of SL on both cognition and agency (which is linked to the affective domain).

Because SL projects are used in a range of academic disciplines that differ in design and scope, the outcomes from SL projects are largely reliant upon effective program design and high-quality placements. Eyler and Giles (1999) identified best practices for SL. These include high quality placements that afford students the opportunity to engage in meaningful work, have important responsibilities, take on challenging and varied tasks, work directly with community partners, receive support and feedback from the partner staff, and be completed over a sustained, more-long term period (pg. 190). In addition, student outcomes are also influenced by SL programs design, which can be enhanced by incorporating application of course content to the field, exposure to diversity to multiple perspectives, and adequate opportunities for written and oral reflection (Eyler & Giles, p. 170-171, 177).

Service-Learning in STEM

There is growing concern in the U.S. over K-12 student achievement in STEM and high attrition rates from STEM majors in higher education. Recent initiatives such as the "Educate to Innovate" campaign by the Obama Administration in 2009 and Learn and Serve America Higher Education STEM grants in 2010 aim to improve the participation and performance of U.S. students in STEM. These grants target innovation in STEM education in the U.S. and identify best practices to expand and diversify the demographics of students who pursue STEM in higher education (Chen, 2013; Hamerlinck, 2013).

Fairweather (2008) relates the decline in undergraduate enrollment in STEM to poor pedagogical techniques in college science courses and calls for use of "evidenced-based instructional practices" (EBIPs) such as active learning to move away from traditional lectures and scripted labs. SL is considered one type of EBIP with many benefits that could improve STEM pedagogy, as well as develop specific professional and research skills students need to be successful in their careers. A recent article by Reynolds (2010), for example, highlights the value of research-based SL (RSL), in which students' service includes participation in scientific field research, as a tool for building scientific literacy. RSL highlights the value and application of unique pedagogical approaches in STEM that allow students to apply the scientific concepts to relevant contexts. Brubaker and Ostroff (2000) identify SL as a tool that can increase understanding of the role that science plays in society. They document the specific benefits from SL STEM to include providing career exposure to students, enhancing academic content through real-world experiences that cannot be emulated through an in-class lab or lecture, and building research and scholarship for both faculty and students.

Though many articles have been written over the past twenty years that emphasize the general skills and attributes gained through participation in SL, the body of literature on STEM-specific courses is quite minimal, particularly with regard to introductory-level courses. Moreover, Hayford et al., (2015) who conducted a literature review of SL STEM, found that current literature is lacking rigorous research design. In many studies, the SL component was not well integrated and limited in scope (three-six hours in total) (Cawthorn et al., 2011; Leege & Cawthorn, 2008; Packer, 2009; Kennell, 2000; Ng & Ling Ling, 2012). Because many of these projects were limited in time frame, it is difficult to assess whether the findings were attributed to service participation or to other variables such as instructor quality, class demographics, quality of reflection exercises, etc.

In order to gain a broader sense of the current literature on this subject and how they address student outcomes, a literature review of SL projects that took place in STEM courses over the past 10 years with a particular emphasis upon literature from general Biology and environmental science courses was conducted. SL STEM has expanded in recent years due to the efforts of initiatives such as Learn and Serve America (LSA) grant program, however current literature does not yet reflect this growth. Moreover, in light of SL STEM expansion, as well as the pressing need for an educated STEM workforce to support the U.S. economy, there is a great need to identify the unique skills, both cognitive and affective, that develop in the STEM courses and to assess how participation impacts students so that best practices can be identified.

<u>Growth in the Cognitive Domain</u>

One major concern expressed by STEM faculty with regard to the adoption of SL curricula is that course content knowledge will be sacrificed and that SL is not rigorous enough to meet these demands (Brubaker & Ostroff, 2000). Indeed, current literature on SL STEM has mixed findings on course content growth. While most of the current literature in SL STEM showed a positive relationship between SL and growth of skills in the affective domain, few studies were able to show a strong link between SL and growth in knowledge of course content/scientific concepts as a result of participation. This may be partly attributed to the fact that many of the studies were designed to gain a general assessment of the benefits of SL in STEM courses rather than specifically targeting learning outcomes as a goal. Cawthorn et al. (2011), for example, looked more generally at how SL participation affected environmental worldview using the Student Assessment of Learning Goals (SALG) survey instrument to measure environmental responsibility and student reflections. Academic growth was minimal in this study. Packer (2009) also used a survey instrument, the New Ecological Paradigm (NEP) to assess pre/post feelings about the environment rather that measure specific course content gains. This instrument asked general questions about feelings toward the environment rather than specific course content questions and therefore was not aligned with course learning objectives.

From the survey of literature, only a few studies specifically measured learning outcomes in their courses (Ng & Ling Ling, 2012; Felzien & Salem, 2008; Tawfik et al., 2014). Data from these studies did show that students experienced moderate to significant academic gains after participation in SL when measurement techniques were more focused upon this.

Pedagogical design appears to be a critical component in achieving positive gains in course content growth. Current literature on SL STEM suggests that the more comprehensive and integrated the project, the more effect SL seems to have on student achievement. Tawfik et al. (2014), integrated problem-based learning (PBL) with SL. In their study of a non-majors Biology course, they found modest to significant gains in student achievement after SL participation. Academic learning was measured using both a pre/post science skills assessment and final exam scores. Students in the course participated in the remediation of a polluted urban lake near the university and made recommendations for addressing the problem. The SL project was well-integrated with course concepts and required 10 hours of service in addition to the completion of a comprehensive group project about the lake.

Felzien and Salem (2008) also showed that the complexity of the service project positively impacted cognitive outcomes. Students in this study were placed at three different project sites, which included serving at a community garden or teaching interactive science lessons to elementary or high school students. Final exam scores and in-depth reflection papers were used to assess student growth. The students who served in the high school showed the greatest level of academic growth, which the authors attribute to the fact that this service required a high level of academic complexity and required students to apply and teach complex course concepts to others.

Daniels et al. (2015) studied the effects of research-based SL (RSL) on health majors at a historically black college/university (HBCU). The primary purpose for incorporating RSL was to improve retention rates among health majors, which were often low due to the abstract nature of the curriculum and limited opportunities to link content to real life contexts. This SL project was very in-depth and engaged students in the research, design, and implementation of the project over the course of an entire semester. Study results show that students experienced significant academic growth in content knowledge and 100 percent of students in the survey identifying that their pre-participation SL goals were met.

Finally, a recent study by (Bernot et al., 2018) found that the use of curricula based on scientific inquiry that was aligned with the Next Generation Science Standards (NGSS) resulted in academic gains in a biology course.

Overall, current literature in this field shows that nearly all students enjoy SL experiences, but not all projects are able to build increased content knowledge acquisition. This illustrates that for growth in science literacy to occur in SL STEM courses, courses must be specifically designed to build and assess academic skills. SL projects are more successful at building scientific knowledge when projects are closely aligned with course content.

Growth in the Affective Domain

In general, the literature on SL STEM showed a positive relationship between participation in SL and the affective domain, for example improved feelings towards both the course and science/environment (Dukhan et al., 2008; Felzien & Salem, 2008). Packer (2009) for example, examined the impacts of service learning on students' attitudes and values towards the environment in an introductory biology course and found the relationship to be positive. Growth in environmental stewardship and sense of environmental responsibility were noted as key findings in several studies (Felzien &

Salem, 2008; Leege & Cawthorn, 2008; Hayford et al., 2015; MacFall, 2012; Ng & Ling Ling, 2012; Packer, 2009).

Other studies noted changes in student attitudes towards the environment, as well as an increased sense of civic responsibility from participation (Cawthorn et al., 2011; Packer, 2009; Ng & Ling Ling., 2012). Packer (2009) for example, used the New Ecological Paradigm (NEP) instrument to assess introductory biology students' attitudes and values towards the environment before and after participation in an SL project at a local farm. Project activities related to course concepts and students reported increased feelings of environmental responsibility after participation.

Ng & Ling Ling. (2012) and Cawthorn et al. (2008) both note student changes in their belief that they could make a positive change to the environment as a result of SL participation. Dukhan et al. (2008), for example found that engineering students who participated in an SL project to upgrade heating systems for low-income families had an increased sense of identity as engineers and improved attitudes/understanding of the role engineering could play in solving social problems.

Though not explicitly stated as an outcome of SL participation, many of the studies in SL STEM that address affective growth that can be associated with growth and development of student agency. More research that explicitly addresses agency and its impacts upon it the SL experience is greatly needed.

Development of Agency in SL STEM

The development of student agency plays an important role in the SL learning process. Agency, defined by Bandura (2000), as the capacity to affect change and to take action in a social context, is linked directly to active experimentation in the ELT cycle.

As students apply content knowledge to concrete SL experiences that address complex and often ill-structured community problems, they are faced with the questions of how they will apply and use this new knowledge and what their role will be in addressing these issues in the future. Through reflection and exposure/involvement to complex issues, students are challenged to re-evaluate their own lives with respect to the community issues and to examine their identities/role within them. Thought and action merge in SL settings. A student's level of engagement/investment in the SL project and the roles they play throughout this process, which in the context of this study can be described as student agency, can impact how a student perceives their ability to affect change in the larger context of the issues they are addressing both during the project and into the future.

Student agency in SL STEM has the potential to impact how students view science and their role as citizens in the scientific process. As scientific issues increasingly intersect with daily life, there is a great need for increased citizen knowledge and engagement in science. SL not only builds content knowledge, but also provides meaningful exposure and involvement with scientific problems as they apply to local issues. In SL STEM courses, students feel that they have a role in solving scientific problems, which has been shown to build self-efficacy and agency (Yeh, 2010). For students who have had limited exposure or confidence in science, SL projects provide these students with opportunities to take on new roles in science that they may not have seen themselves in before.

Development of student agency has been linked to growth in self-efficacy (Bandura, 2000) and science identity (Basu, 2008; Barton & Tan, 2010). Incorporating pedagogical practices such as SL into science courses gives students the opportunity to develop agency and could also help develop interest in science and improve retention rates in STEM in higher education.

The concept of agency has been debated by the sociological and psychological community with regard to the specific factors that influence on human behavior. Bandura (2000) links agency development to social cognitive theory and attributes it to positive growth in self-efficacy, which is described as the belief that a person can "produce desired effects and forestall undesired ones by their actions" (pg. 75). According to Bandura, agency gives people the capability to "influence the course of events and to take hand at shaping their lives" (2000, pg. 75). It can affect how people view goals, aspirations, outcome expectations, perception of challenges, and opportunities.

There are a range of definitions used in literature to describe agency. Basu (2008) describes agency as, "purposefully considering and enacting both small and large scale change in personal and community domains, based on one's beliefs and goals" (p. 891). Barton and Tan (2010) define agency as, "the capacity to act towards the realization of personal goals, aspirations and values."

For the purpose of this study, agency was defined in two ways: 1) level of engagement/investment in SL projects during participation and 2) how students viewed their role in the issues they were addressing in the future. Level of engagement/investment was defined by student participation/enthusiasm levels in the projects as well as the specific roles and identities they took on while serving. Agency in this context was developed through participation in a self-selected SL project that best matched their interests and schedule. The SL project provided concrete experiences in relevant contexts for students to play a hands-on role in addressing scientific issues that face the community and to evaluate their role within this.

There has been an increased interest in student agency in educational research in recent years, particularly as it relates to science education This interest can be attributed to science curricula that is often irrelevant to students lives and not accessible or equitable to many students. Basu (2008) believes that student agency has the potential the influence large-scale social change, particularly in STEM education because it increases both access and relevancy. Barton and Tan (2010) discuss the idea of “critical science agency” (CSA) in their article, defined as “a person’s intentions to cause change in their own lives or the lives of others utilizing scientific knowledge” (p. 194). In their study, Barton and Tan (2010) measure the development of CSA by assessing how youth assert themselves as community science experts in a community-based science program on green energy. They found that in out of school settings, youth often challenged their traditional science roles and were able to build science identity. Basu (2008) explored the idea of CSA by measuring how two immigrant students enrolled in a high school physics course developed and expressed agency over time. The authors described agency development in their study as both an iterative process, in which a person re-evaluates their knowledge and identity over time, and a generative process, in which a person expands their knowledge, sphere of interactions, and level of personal influence in science, which enables them to access new types of capital. This links to the idea that increased agency in science can increase a student’s capacity to meet their personal goals, aspirations and values.

Although no literature in the field of SL has explicitly explored the idea of agency to date, some literature has assessed SL's link to self-efficacy, personal development, and citizenship (Eyler & Giles, 1999; Dukhan et al. 2008, Felzien & Salem, 2008; Yeh, 2010), with all of these affective skills having an impact on agency development. Felzien and Salem (2008) studied the impacts of SL on low income first generation (LIFG) high school students enrolled in an out-of-school engineering program. They found that participation in the program not only helped the students build social and cultural capital (both with regard to knowledge of the engineering field and how college works) but also positively impacted their sense of self-efficacy and identity as future engineers/scientists. Daniels et al. (2015) looked at the impacts of SL on underrepresented students in STEM and studied the effects of RSL on health majors at a HBCU. Study results show that SL had tremendously positive results which included growth in social capital (connections within the community and with peers and faculty alike), self-efficacy, and leadership skills. Yeh (2010) also connected SL participation to gains in social and cultural capital and self-efficacy among LIFG students as students gained knowledge of community and university resources and also had increased opportunities to dialogue with their professors and peers about university culture through the projects. Finally, a recent study by Bernot et al., (2018) measured academic growth in a biology course. Their assessment also included data that rated student enthusiasm in the projects and found growth. Level of enthusiasm can also be associated with agency development.

Although recent literature in SL STEM, and efforts to improve SL STEM education in U.S. have primarily focused upon shifts in pedagogy, less emphasis placed upon the role of the SL project/STEM experience upon student outcomes. In this study, the emphasis will shift to student outcomes, specifically content knowledge and agency development, within SL projects. One of the primary goals is to identify which types of SL projects are best at fostering agency and what are the general characteristics of these projects. The goal of this research is not only to provide insight into best practices in SL STEM, but also to promote increases in interest and participation in science. The methodology that guides this research will be discussed in the next chapter.

CHAPTER 3: METHODOLOGY

The primary purpose of this mixed-methods case study is to consider how participation in different SL projects in an introductory environmental science course at a mid-sized urban university impacts student course content knowledge and agency. Both qualitative and quantitative data were collected to assess course content growth and analyze development of agency across all SL projects. These data were then compared across SL sites to assess for similarities and differences and to gain more insight into the characteristics of projects that best foster these skills/values. The research questions that guided this study were:

1. How does participation in service-learning, in an introductory environmental science course, impact students overall course content knowledge and agency?
    a. What, if any, are the correlations between course content knowledge and agency development?
2. How do course content knowledge and agency differ across SL project sites?

This chapter describes the research design, setting, timeline, and data collection methods and analysis that were used in this mixed-methods case study. The first section provides an overview of the mixed-methods research design, which drew upon both qualitative and quantitative data to increase reliability and give a more holistic picture of the phenomenon (impacts) that occurred during SL participation. In the second section, the site, participants, course, and SL projects are described to provide context of the problem that was explored by this research. In the third section, the data collection methods that were used for the study are described in detail. This is followed by a data analysis section that details the specific mixed- methods procedures that were used to carry out the research, including the coding framework and statistical analyses that were used. The chapter concludes with sections on trustworthiness and subjectivities that address and expose limitations of the research design.

Research Design

This study employed a mixed-methods design using a balance of qualitative and quantitative methods (Creswell & Plano Clark, 2015). Quantitative methods were used to compare course content knowledge and student agency across time and to compare change across the four categories of service experiences. Qualitative methods were used to gain a deeper understanding of the student experience, provide specific examples, and add descriptive language and student voice to the data (Creswell, 2013; Saldana, 2016). Quantitative and qualitative method were well balanced in this study, although qualitative methods were give due slightly more weight to overall due to the use of partner interviews to corroborate student data. By linking this data, relationships between student outcomes and the types of projects that support them were examined. Inferences were drawn about what characteristics of SL projects seem to draw the most benefits for students.

Employing a mixed-methods approach gave the study a more holistic picture of the phenomenon (impacts) that occurred as students participated in SL projects in the course and allowed for data to be confirmed, cross-validated, and corroborated (Saldana, 2016). This study used a convergent parallel design (Creswell and Plano Clark, 2015) in which data were collected concurrently in two phases (pre/post), analyzed separately, and then merged to look for similarities and contrasts. Using the convergent parallel design allowed inferences and correlations to be drawn about how course content knowledge and student agency were impacted through SL and which type of projects best fostered this growth (Creswell and Plano Clark, 2015).

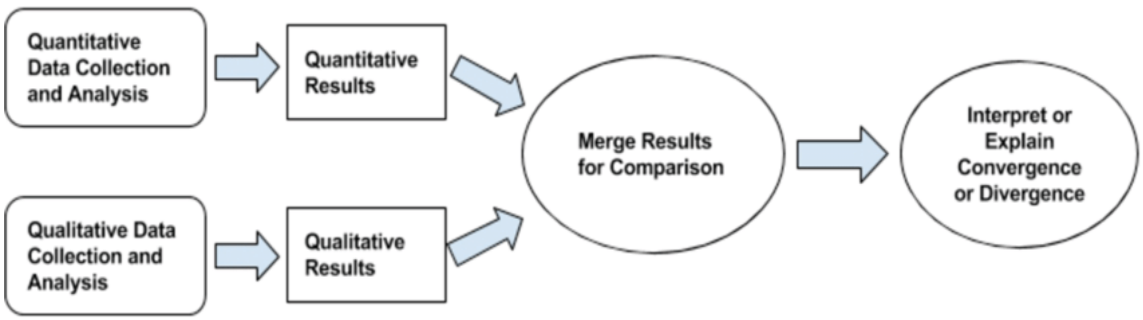

Figure 3.1 Convergent Parallel Design (Creswell and Plano Clark, 2015, p. 56).

Paradigmatic corroboration, which is the analytic comparison of qualitative and quantitative methods, was used to compare themes found in both data sets and look for key differences (Saldana, 2016). These data were also compared across SL sites. This allowed for greater triangulation and comprehensive coverage of the case study. In addition, using a mixed- methodology allowed the study to draw upon the strengths of both methods. For example, course content knowledge can be difficult to measure qualitatively and conversely, student agency can be difficult to measure solely from quantitative survey data.

The study design involved a single case study with two embedded sub-units (Yin, 2003). The “case” was participation in the SL project and the outcomes from participation (course content growth and agency development) were the embedded sub-units of analysis. According to Yin, “compared to other methods, the strength of the case study methods is its ability to examine, in-depth, a ‘case’ within its real-life context” (p.

111 in Green, Camilli, & Elmore, 2006). Using an embedded case study design allowed for the integration of both quantitative and qualitative methods in a single study and enabled more thorough analysis of the sub-units (Scholz & Tietje, 2002; Yin, 2003). For this study, a case study was selected to more thoroughly describe and assess the phenomenon (impacts) that occurred when students participated in different SL projects. In addition, this course was both representative and typical of many introductory, non-majors college science courses and therefore generalizable.

Setting

The information below highlights the site, participants, course, projects, and timeline that were used in this mixed-methods case study.

Site

This case study took place at a mid-sized, metropolitan university in the western part of the United States. Eighty-three percent of the approximately 24,000 attending students at the university are undergraduates with an average age of twenty-four and a half years. White students represent 73 percent of the student body with Hispanic students representing the largest minority group on campus at 13.5 percent. The university has seen a rapid growth in enrollment in recent years, particularly from out-of-state residents, who currently represent 29.4 percent of the student body and 45.3 percent of incoming freshman. As a result, non-traditional student numbers are on the decline and the average student age is decreasing as the university recruits students directly out of high school (Boise State University, 2018). The university's SL program "connects classrooms with the community through capacity-building partnerships in order to enhance student learning, address critical community issues, and encourage students to be active citizens in their local, national and global communities." (Boise State University Service Learning Program, 2018). The program is well-established and has offered SL courses to over 33,000 students since its inception. These opportunities include "160 courses offered in 44 departments each year and 100 community partners." (Boise State Service Learning Program, 2018).

Participants

Eighty-nine students enrolled in two sections of an introductory environmental science class were recruited to participate in the study. SL projects were integrated into the course content. Students were given an option to complete a SL project, which involved hours of service, or write a research paper. Eight students opted out of the SL project and 14 either did not complete the surveys or dropped the course mid-semester; thus, 67 students participated in the study. Students in both courses represented a wide range of backgrounds, ages, and experiences that well reflect the diversity of the university. Sixty percent of students were freshman and sophomore non-science majors who were taking the course to fulfill a required natural science requirement. Several of the students in the class were participants in programs such as TRIO, which support first-generation college students, CAMP, which supports migrant farmworkers, and the university's veteran's services program. As the course is a requirement for the Environmental Studies major, 15 percent of the students in the course were environmental studies majors and minors. In previous semesters, many students enrolled in the course expressed that were taking this course because they did not feel that they have the science skills to succeed in other disciplines such as chemistry or physics.

<u>Course</u>

The environmental science course used for this study was part of the general education curriculum at the university and satisfied a required natural science requirement. The content provided an introduction to environmental science, which included both scientific foundations and application to the human dimension. The course explored interdisciplinary topics that linked science and technology with humans and the environment. It integrated scientific, sociopolitical, and humanistic approaches to the understanding of ecosystems and consideration of how humans interact with the natural world. The course examined real-world environmental issues and demonstrated how the scientific method and interdisciplinary approaches were used to formulate questions and test observations. A detailed copy of the course syllabus can be found in Appendix E.

In addition to the environmental science content, the two sections of this course that were included in this study both had an integrated SL component that was well-integrated and aligned with both university and course learning objectives. The instructor integrated SL into the course throughout the course, incorporating SL examples into Powerpoints, creating class discussion questions related to the projects, and encouraging students to include information on SL projects into group presentations on local topics. Both sections of the course included in the study were taught by the same instructor. This instructor has taught the course over 30 times in both in-person and online settings over the past six years. The instructor has extensive knowledge of SL and has been made significant adjustments to the course assignments and reflection activities over the past five years based upon student feedback and evaluations from the SL office on campus in order to create a learning environment that aligns with Kolb's ELT model. The teacher's motivation for incorporating SL into the course was based upon the desire to create an accessible learning environment that encompassed active learning and created opportunities to meet the diverse needs/range of students enrolled in the course. Course learning objectives and specific weekly topics can be found on the course syllabus in Appendix E.

In addition, each semester, the instructor provides a copy of the syllabus and learning goals to the partner agencies at the start of the semester to ensure alignment and encourage the partner to facilitate dialogue around course topics as they pertain to the projects.

<u>SL Projects</u>

Both sections of the course included in this study had an integrated SL component where students completed fifteen hours of service at a local on-profit or government agency outside of class time. Students connected their service to course content throughout the semester through a series of assignments and reflection activities. During the fall 2018 semester, the course had six SL community project partners that were linked to the class. The majority of the community partners had partnered with the course for at least one year, with some linked for over six years. One additional project was added at the last minute due to staff changes at one of the long-term SL partner agencies. However, this project will not continue in future semesters so was not included in all parts of the data collection and analysis.

All the projects, with the exception of the newly added project, were considered to be “level one” projects by the campus SL office, meaning that students do not need specialized academic or technical skills to be able to participate. Students were given a choice of projects to choose from based upon their availability and interest areas. Community partners attended the class at the start of the semester to give an overview of their projects/expectations and field student questions. These projects were selected by the SL office and instructor based upon their connection to course concepts and ability to take on large groups of students with limited technical skill sets. Although all SL projects teach different skill sets, they were all aligned with course learning objectives and provide opportunities to apply course concepts in the field.

Five of the six project partners for the Fall 2018 were grouped into three general categories that are described below. A sixth partner, a policy project, was added at the last minute and did not fall into one of the major project categories. Unlike other SL partners, this project did not have a long history with SL and had not participated in conversations with the instructor about course learning objectives or student needs. For this reason, the information for this project was included in the table below, however, since it was a one-time project and was not a well-aligned to course content, partners from this project were not interviewed. In addition, the pre/post test questions on the course content assessment did not include questions related to this project. Student data from this project, however, was included in the analyses that measured student changes in course content and agency before and after participation and this project was added as a SL condition in the correlations data used to analyze research question two. The rationale for including this project in these analyses was to increase the overall N for the project and increase internal validity.

Table 3.1 SL Project Overview - Fall 2018

Type of Project	Common Project Activities	Depth/Scope of Project
Land Use Management: Habitat Restoration/Trail Building	• Trail maintenance and building, bridge construction, signage, erosion control • Invasive weed control- cheatgrass removal • Planting sagebrush and collecting sage brush seeds after wildfires	• 15 hours of service • Completed in larger chunks of time (five-seven hrs./session) • Physical labor • Often work alongside other community members • Partner provides detailed education related to topic in conjunction with service activities
Agriculture: Gardening	• Composting • Planting, weeding, harvesting, putting beds to sleep at	• 15 hours of service • Completed in smaller service chunks (three-four hrs./session)

	school and community gardens • Staffing a community harvest event	• Physical labor • Partner works closely with students in team atmosphere • Opportunities to work alongside community garden members • Partner provides specific instruction on the project tasks at each session
Sustainability: Recycling/Waste Management/Education	• Waste assessment (weigh trash, weigh food waste, compare) • Hands-on recycling at large events • Created displays, art • Recycling education of	• 15 hours of service • Completed in smaller service chunks (two-five hrs./session) • Not physical • Many different tasks combined to achieve larger theme

	students and community members • Researched zero waste best practices	• Extensive education on service goals provided • Opportunities to educate other students and citizens
Non-profit Policy and Education (added last minute – data not included in partner interviews or student reflection journals).	• Researched policy issues related to Idaho rivers • Created podcasts, stories, and other social media marketing tools for the website • Taught water education curriculum to elementary-aged students	• 15 hours of service (varied times) • Not physical • Variety of tasks – some individual research on own time • Some students will work directly with children and develop curriculum • Partner availability varied

Data Collection/SL Project Timeline

The research data that was collected were based upon student participation in a 15-hour SL project that was integrated with course material from the introductory environmental science course. The data were collected over the course of a one 16-week semester during the fall of 2018. At the start of the semester, students selected a SL project from a list of six sites that best matched their interests and schedule. Community partners visited class to give an overview of their projects and the tasks involved. In addition, many academic assignments in the course were aligned to integrate SL experiences. Students recorded their reflections regarding the SL experience through an online SL reflection journal. This included perceptions of the project before engaging in the SL experience as well as after participation. After completing the projects, the students participated in a SL reflection session facilitated by SL staff at the university. The students then worked in teams to create digital reflection posters that documented their SL experiences and connecting these ideas to course concepts. Each team was comprised of three to five students from the same SL project. Students presented their reflection posters to the class and winning posters (as selected by the class) were shown at a university-sponsored SL poster exhibition at the end of the semester. These students presented their posters to members of the community and university. In addition to creating posters, students in the course also completed a final project for the class in which they proposed a research question related to their SL project to explore. They used the scientific method steps and data collected from both research and the SL experience to address the question and interpret their findings. They then created an infographic that detailed the data they collected and supporting evidence they found, as well as conclusions applied from SL participation.

Table 3.2. Service Learning Project Timeline

Week	Service-learning Activity	Details
Week 1	• SL project partners and SL office visited the class • Students received access to OrgSync, an online platform that provides information about projects and enables students to sign-up	• SL office gave detailed overview of SL and value to class; also showed how to use OrgSync platform • SL partners gave five-minute presentations about their projects and answered student questions
Week 2	• Students registered for a project on OrgSync • Students completed course concepts pre-test (ungraded)	• 40-question concept test was divided into three categories that were linked to projects
Week 3	• Students attended one-hour on-site orientation to the project with community partner to learn more about the projects • Students completed pre-service reflection journal	

	• Students completed pre-service agency survey (nine questions)	
Weeks 4-15	• Students completed service hours with SL projects	
Week 7	• Students completed an informal midpoint check-in during class	
Week 13	• Students attended a 1.5 hr. in-class reflection session with SL office personnel • Students created SL research posters in teams of three to five	• Activities included individual and group reflection • Teams were selected by the instructor based on SL project - grouped by SL project
Week 14	• Oral presentation of posters by teams, class voting • Students completed final online reflection journal • Students completed post-service agency survey (nine original questions from pretest and 13	• Top five posters selected by class go to university-wide poster session to compete for Best of College

	additional based-upon SL experience) • Partners interviewed about the SL experience	
Week 15	• Final SL hours were due on OrgSync platform • Course concepts post-test (40-questions - ungraded) • Attend university poster show (optional) • Final project (SL infographics) due • Infographics sharing session (in-class)	

As the instructor for the courses and the researcher for this study, I was able to closely monitor the progress of students throughout the semester both in-class and at the project sites. In addition to the above information, I interacted with students in class on a twice-weekly basis and received informal feedback on their experiences throughout the course through emails, one-on-one conversations, and class discussions. I also maintained close contact with community partners throughout and completed site visits at several projects to observe student engagement levels in the projects. I integrated SL project activities into class discussion as often as possible to tie course concepts back to the SL experience.

Data Collection Methods

Quantitative data and qualitative data were collected concurrently in two phases (pre/post) using the convergent parallel design. Data collected from both methods were first analyzed separately and then compared and contrasted side by side to look for convergence, divergence, contradictions, or relationships between to two sources of data (Saldana, 2016). They were then merged to yield an overall interpretation of the data (refer to Figure 3.1).

Quantitative Data

Pretest and Posttest Course Content Assessment

Students were given a 40-question multiple-choice course content assessment at the start of the course and after completion of SL. This assessment is included in Appendix C. The purpose of this assessment was to measure course content knowledge growth before and after service. Questions on the survey included 10 general course content questions that were not directly linked to material covered in SL. The other 30-questions were grouped into three categories (10 questions each) that were linked directly to the SL project type described in Table 3.1. For example, students answered 10 questions directly linked to recycling, 10 directly linked to agriculture, and 10 directly linked to land use. The rationale for this design was to create a way to differentiate between gains linked specifically from in-class course content and knowledge that was gained through SL experience. Asking 10 questions that are not linked to SL also helped identify academic outliers such as students with significant prior knowledge in the course. In addition, creating questions that were closely aligned with the specific SL experiences provided a more accurate picture of gains related to SL rather than general course content. Categorizing the questions by content area gave further insight into which specific content areas/concepts students gained information about during participation.

Forty-four students completed both the pre and the post content assessment and were included in the analyses. Twenty-three students who took the pretest were not able to complete the post assessment because it was not set up correctly in the testing software, therefore some students data was not properly saved and could not be included in the analysis. This is discussed further in the limitations section of chapter five.

Pretest and Posttest Student Agency Survey

Students were given a nine-question pre/post Likert survey that assessed student agency levels before and after participation. These questions are included in Appendix B. These questions asked a range of questions relating to student experiences with environmental studies, science courses, and community service experience to gain a sense of student agency before entering the project and to assess how the SL experience affected this.

Because student agency is difficult to measure before participation, the post-service agency survey included an additional 13 post-service questions that were specifically designed to measure student agency during the SL project, as well as measure how SL participation impacted agency in the future. These questions provided a more effective measurement tool for assessing agency than the pre/post agency questions since they were tied directly to the SL experience and the student's identity within the projects. In addition, the post-service survey questions were well-aligned with the research questions and to the definition of agency in the context of this study. The 13 questions were grouped into two categories, one that assessed agency during project and the other assessed future agency. These questions are listed in Appendix B. Scores from the two categories were then totaled and combined.

Post-Service Survey: Course Content Questions

Two additional questions were added to the post-service survey instrument to measure student perceptions of course content growth. The goal of these questions was to provide additional data to support the course content assessment on how course content was impacted by SL. Course content questions are listed in Appendix B.

Qualitative Methods

Qualitative data included: 1) a SL pre/post student reflection journals, 2) post-service interviews with four community partners representing each of the key project categories. As mentioned earlier, the partner from the fourth SL category was not included in the interviews since this project was added last minute and not well-aligned with the course content. Data was collected from students before and after SL participation, and from community partners after SL participation was complete. The goal of collecting qualitative data was to corroborate findings with quantitative analysis and to triangulate this data by using multiple sources (Creswell & Plano Clark, 2015).

SL Reflection Journal

Reflection is a critical component of both ELT and SL. Bringle and Thatcher (1999) discuss the importance of incorporating reflection into the SL process in order for students to make meaningful connections from the experience. Eyler and Giles (1999) discuss effective reflection as a critical factor in connecting service to academic learning outcomes and linking abstract concepts to concrete. Given the value of reflection to the SL process, all students participating in the study completed a graded pre/post reflection journal as part of their participation. This was completed through the online journal feature on the Blackboard Course Management System used at the university and consisted of six open-response questions, which are outlined in Appendix A. The reflection questions were directly linked to the research questions with the goal of assessing changes in content knowledge and agency and to consider how participation in the project affected the students in these areas. The journal was completed in the fourth week of the semester, just prior to beginning the SL project (pre-service), and at the end of the semester in week 15 after completion of the SL project (post-service). The goal of the journal was to allow students to dialogue about their experiences, discuss expectations/outcomes, address challenges they faced, and to identify how participation in SL could be applied to the course and their own lives.

Partner Interviews

Focused, semi-structured, 30-minute long interviews were conducted with community partners at the end of the semester. Four of the six community partners, representing each of the key SL project categories, were interviewed regarding expectations, goals, outcomes, and mission of the SL project. Partners were also asked to provide specific evidence of student learning, attitudes, engagement levels, and participation roles that students had within the context of their project. The interview protocol was directly linked to the research questions and is included in Appendix D. The purpose of the interviews was to “hear” the partner’s voice and gain insight into their opinions regarding student participation and agency. Yin (2003) cites the value in using interviews as a tool to corroborate opinions gained through other relevant sources/data collected. Partner interview data was used to corroborate data collected from the students and also to inform the discussion section of this study. One of the primary goals of this research was to determine which types of projects result in the greatest gains in agency and course content growth, so it was essential to have the partner's voice to compare and contrast with student experiences.

Table 3.3 Summary of Data Collection Tools and Timeline

Data Collection Tool	Case Study Embedded Sub-Unit Measurement	Type of Data	Timeline: Pre-SL	Post SL
A) 40-question Course Content Pre/Post Assessment	Course Content	Quantitative	**X**	**X**
B) Agency Survey (nine question	Agency, Course content	Quantitative (pre/post)	**X**	**X**

pre/post, 15 additional post-service questions)				
B) Online SL Reflection Journal (with six guided questions)	Agency, Course Content	Qualitative	**X**	**X**
D) Semi-structured Interviews with Community Partners	Agency, Course Content	Qualitative		**X**

Data Analysis

In the section below, the specific quantitative and qualitative analyses that were used in this mixed-methods case study research are described.

Quantitative Data

Quantitative data included: 1) pre/post content assessment 2) post-service agency survey questions. To evaluate possible differences in course content knowledge from pretest to posttest across the different SL projects (Research Question 1), I conducted a 2 (Pretest versus Posttest) x 4 (SL Projects: agriculture, recycling, and land use) analysis of variance (ANOVA). The ANOVA tested the significance of change from pretest to posttest, differences across the four SL projects, and the interaction between these variables (i.e., evaluates whether change from pretest to posttest is consistent across the SL groups).

To evaluate possible differences in student agency from pretest to posttest across the different SL projects (Research Question 1), I conducted a 2 (Pretest versus Posttest) x 4 (SL Projects: agriculture, recycling, and land use) analysis of variance (ANOVA). The ANOVA tested the significance of change from pretest to posttest, differences across the four SL projects, and the interaction between these variables (i.e., evaluates whether change from pretest to posttest is consistent across the SL groups).

I also examined the correlation between knowledge and agency to evaluate whether change in knowledge was related to agency. To do this, I correlated student pre/post content assessment scores with scores on the post-service agency survey.

In addition to this, student data from a Likert-scale (1-5) post-service survey was used to assess how students perceived their growth in content knowledge and agency. Two questions were added to the post-service survey instrument that specifically measured perceived content gains after SL participation. Mean scores from these questions were analyzed. Thirteen questions from the post-service survey instrument measured student perceptions of agency growth. The means from these scores were compared these between projects. I conducted a 1 (Post-service Agency Survey Score) x 4 (SL Groups: Agriculture, Recycling, Land Use, and Policy) ANOVA to compare scores from the post-service agency survey scores by project site.

Finally, reflection journal scores were qualitatively coded using the framework described below. These scores were then quantified. This allowed me to test the relationship between coded reflection journals and pre/post survey scores. I scored the reflection journals of 13 students using the agency and coding framework (see table 3.3) and correlated these data with the pre/post scores on the agency survey to see if these measures were aligned.

<u>Qualitative Data</u>

Qualitative data was coded using two different coding methods: 1) a coding framework and 2) open-coding. Data collected from pre/post reflection journals was coded using two different coding frameworks that were designed by the researcher and based upon the literature. One coding framework assessed student agency during the project and in the future, while the other assessed course content knowledge. The agency coding framework was categorized based on student agency characteristics described in the literature review and was used to analyze student responses and reflections. The course content coding framework was focused specifically on the level of content rigor exhibited by students in their reflections, as well as how they connected course content knowledge to the project tasks.

In addition to the coding frameworks, open coding was also used to analyze the semi-structured interviews with community partners. Data from partner interviews was analyzed line-by-line to look for key similarities and differences, as well as to identify dominant and emerging themes (Saldana, 2016). The data was re-coded through an iterative process to identify key thematic codes which were grouped into clusters around similar or interrelated ideas or concepts. These codes were then grouped into key categories, with subcategories linked to them. These codes are listed in chapter four.

Reflection Journals

An agency coding framework was used to analyze student reflection journals. The agency coding framework measured student agency in two major areas: 1) agency exhibited by students during the SL project and 2) agency students plan to exhibit after participation. The framework included three levels of agency for each of the two categories: high, medium, and low. Each category and level were given a numerical value and a description of what agency looks like at that level. See table 3.3 below.

Table 3.4 Agency Coding Framework:

Agency Category	Level 1 - Low Agency	Level 2 - Medium Agency	Level 3 - High Agency
1. Agency in Project: (Roles, Engagement, Investment. Efficacy)	1.1 Characterized by:	1.2 Characterized by:	1.3 Characterized by:

	• Reflection may not be very in-depth • May discuss challenges relating to project completion such as scheduling, communication, personal life, etc. • May describe SL experience in negative or apathetic light • May describe SL as a waste of time or simply a course requirement • Limited or negative discussion of partner role in project	• Reflection may be complete but limited in depth • May discuss SL in a positive light but also highlights challenges relating to project completion such as scheduling, communication, personal life, etc. • May describe taking a more passive role in project activities rather than leadership.	• In-depth reflection • May describe their role in the projects as more of a leadership role or describe how the project translated to their own lives • Discusses personal engagement level, investment, and/or personal growth in a positive light • May discuss completing extra

	• Limited connection of SL to personal growth, environmental worldview	• Addresses how community partner communicated and valued participants in and how this shaped the experience • May highlight social aspects of the project more than mission. • May describe personal growth and initiative as limited	hours at the project site • May discuss how they got family members or friends involved with them • Addresses how community partner communicated and valued participants in a positive light and how this shaped the experience
2. Future Agency	2.1	2.2	2.3

	• Limited or no plans to volunteer with agency or related issue in the future • Limited discussion of lifestyle changes as a result of SL • Limited shifts in environmental/scientific worldview. Limited discussion of application of project to daily life	• May express some interest in volunteering in the future with the agency or with another agency • May discuss changes in environmental or scientific worldview • May describe increased interest in application of environmental issues to daily life	• Plans to continues to volunteer at the agency or related project • Plans to shift majors/minors to an environmentally or ecologically themed major • Discusses personal lifestyle changes made during the semester and expresses plans to make further

		• May describe making some lifestyle changes related to SL (for example home composting) • SL experience may not impact major/career plans	changes in the future • Mentions future plans to get related internships, opportunities

A course content coding framework was developed to focus specifically on the level of content rigor exhibited by students in their reflections, as well as how they connected course content knowledge to the project tasks. The framework included three levels of course content rigor for each of the two categories: high, medium, and low. Each category and level were given a numerical value and a description of what rigor looked like at that level. See table 3.5 below.

Table 3.5 Course Content Coding Framework

Course Content: Level of Rigor	Level 1 - Low Rigor	Level 2 - Medium Rigor	Level 3 - High Rigor
	1.1 Characterized by: • Mentions broad course concepts rather than specific topics • Limited discussion of how course concepts relate to specific project activities or larger community/environmental issues	1.2 Characterized by: • Discusses course concepts but may not discuss the specifics or how they apply to the larger ecosystem • May not provide specific examples or how content from class was applied to project activities	1.3 Characterized by: • Discusses specific content rather than broad. • Has understanding of ecological relationships between concepts • Applies content to larger environmental and community

	• May struggle to describe concepts or project activities. Does not use specific examples.	• May make connections to larger environmental/community issues	issues such as wildfires • Gives specific examples of how project activities connect to course concepts.

The agency and course content coding frameworks were based on literature in the field. Extensive prior knowledge by the instructor about the types of student agency/rigor most often expressed in this course, as well as SL course evaluations also influenced the coding framework designs. Coding frameworks are supported by Ritchie and Lewis (2003), who discuss the method of labels and categories that allows data to be organized and analyzed in a method described as cross-sectional code and retrieve. In this method, the researcher develops a common system of categories which can be applied across an entire data set. This system, or framework, can be used to search and retrieve chunks of categorized data and create a systematic method of grasping the larger scope of the data.

Using coding framework allowed the researcher to use priori coding, in which codes are predetermined (Saldana, 2016), to look for patterns and summarize data in a way that supported answering the research questions. The framework was also used to shed light on the relationship between the types of projects that students were engaged in and the level of agency/course content rigor that students expressed within them. Data was charted and indexed into the agency and course content coding frameworks to assess the impacts of SL both before and after participation. Data was re-read and re-coded in an iterative, cyclical process to ensure validity.

Thirteen student reflection journals were selected for in-depth coding. Three students from each SL project category were selected based on their total agency score on the post-service agency survey instrument described above. Three students were selected from each project category to reflect a range of participants scores. One low scoring student (1-47 out 65 points), one medium scoring student (48-56 points) and one high scoring student (57-65 points) was selected from each project. Four additional students were chosen at random (based upon overall survey scores rather by project) to add to the overall N and increase internal validity. The researcher began by reading through all of the pre and post reflection journals and categorizing responses by agency level and course content application. Responses from Blackboard Course Management System were then cut and pasted into a word document and categorized into the three levels of agency (high, medium, level). To narrow the number of reflection journals to thirteen, the researcher used student scores from the agency post-service survey to select students with high and low levels of agency and to be sure that the students were representative of each of the key SL three project categories.

Quotes were then selected from student reflection journals to add thick description and specific evidence to the data shown by the quantified scores. Quotes that illustrated different levels (high and low) of content rigor were selected from three of the SL project categories. Journals from the policy SL group were not selected for this part of the analysis since this project was not well aligned with course content. In general, a student demonstrating high rigor made specific connections to course content rather than general, and also discussed why and how project tasks were related to course content. For example, a student with high content rigor might explain the relationship between sagebrush loss and the wildlife.

Open Coded Partner Interviews

Open coding is often used in grounded theory research (Glaser & Strauss, 1967), however, in this study, the primary goal of using open coding was to give the community partners a voice in the process and to see if their responses corroborated student data. Semi-structured interviews were conducted with four of the SL partners representing the three key SL project categories.

Open coding enabled the researcher to see if the themes that emerged from the interviews supported the initial hypothesis regarding agency and course content knowledge. It also provided insight into the specific factors and examples within the projects that might positively or negatively impact agency and course content knowledge. Data from community partner interviews was analyzed word-by-word and line-by-line using open-coding to look for emergent and then interpreted into segments (Saldana, 2016). According to Saldana, “qualitative inquiry demands meticulous attention to language and deep reflection on the emergent patterns and meanings of human experience. Recoding can occur with a more attuned perspective…” (2016, p. 10). Four community partners, with representation from the three project categories, were interviewed at the conclusion of the SL projects. Data from the interviews was reviewed through an iterative set of cycles in which data was re-coded and re-categorizing to look for key themes and emergent codes. This data was then compared across SL projects to look for similarities and interrelationships in themes and then clustered into several "parent" categories with "child" subcategories for each category. Coding was completed manually to identify emerging codes. An Excel spreadsheet was then used to record code frequency across interviews. The codes that emerged most frequently were then compared for similarities and clustered into related categories and subcategories described above.

<u>Merged Data</u>

In the convergent parallel design used in this study, quantitative and qualitative data were analyzed separately and were then compared to look for convergence or divergence of the findings. These merged findings were then interpreted and explained in the discussion section of this study.

Generalizability

Although this is a case study taking place at one university, it is highly generalizable to other universities that would like to create SL experience in STEM courses. The demographics and majors enrolled in the introductory environmental science course used in this study are typical of many large, non-majors' science courses at mid-sized universities across the U.S. and abroad. Moreover, because of the average size, demographics, as well as the strength of the SL program at the university in this study, this case study model could be replicated at other universities.

Trustworthiness and Reliability

In order to avoid validity threats that exist in the proposed study and to improve credibility, I used a number of strategies including: a) triangulation of data, b) intercoder reliability, c) member checking, and d) rigor.

Triangulation of data refers to the use of multiple sources and methods to gain a comprehensive understanding of the research phenomena (Patton, 1999). To ensure triangulation of data, I collected data from multiple sources (both students and community partners) and used several data collection strategies that included both qualitative and quantitative methods. As the instructor for the course, I was also closely involved with the research process throughout, although all informed consent was collected by a third party when I was not present. All qualitative research data gathered was coded in an iterative process to increase validity. The agency coding framework was designed based on prior knowledge of student agency in the course, however, it was revised and designed with outside guidance and assistance from a faculty member outside of the SL field.

A third technique to ensure reliability of the study was using member checking, a term used by Creswell (2013) that refers to the participants playing an active role in research. Data was shared with community partners and with staff from the SL office on campus to ensure consistency. Finally, rigor, or use of rich, detailed description (Tracy, 2010) was used throughout the findings section. Detailed descriptions of participant experiences were used to give depth and validity to the research.

Subjectivities

Since the participants in this case study were from courses that I taught, there was a high likelihood that bias impacted my interpretation of the data. Hatch (2002) warns of the danger in teachers researching their own classrooms because of the difficulty in separating research from practice (p. 47). I have made every effort to avoid this, by asking for outside assistance from a third-party in the development of survey and reflection questions and interview protocol. Student consent forms were collected by a third-party and I was not present during the consent process. Students were also given the option of withdrawing from the study and were given the contact information of the third-party consenter rather than myself or the co-principal investigator. In addition, I did not have access to the data until after final grades were submitted for Fall 2018.

My personal pedagogical belief that SL is an effective tool is also legitimate research concern as it could cloud interpretation of the qualitative data. To account for these subjectivities, I have had other faculty in my field who do not use service-learning review my research design.

CHAPTER 4: FINDINGS

This mixed-methods case study assessed how students' course content knowledge and agency development were affected through participation in SL in an introductory environmental science course. Students were enrolled at different SL sites, with one of the goals of the study to identify which types of SL projects were most effective at fostering course content knowledge and agency. The study also analyzed whether there were any correlations between course content knowledge and agency. The overarching goal of the study was to gain insight into the role that SL curricula can play in STEM courses and to help identify best practices moving forward.

Research Questions

There were two primary questions that guided this research:

1. How does participation in service-learning, in an introductory environmental science course, impact course content knowledge and agency?

a. What, if any, is the correlation between course content knowledge and agency development?

2. How do course content knowledge and agency development differ across service-learning sites?

The goal of research question one was to gain insight into the specific outcomes that students gain from participation in different SL projects in a large, introductory-level environmental science course. It was hypothesized that if SL provided opportunities for students to connect abstract concepts to concrete experiences and SL was well-aligned with course learning objectives, then student content knowledge would increase. Moreover, because students were engaged in self-selected hands-on projects in social contexts where they played an active role in addressing environmental problems, it was hypothesized that student agency would increase as well. The research sub-question asked if there were any correlations between course content knowledge and agency. It is hypothesized that gains in course content would also lead to gains in student agency.

The goal of the second question was to assess the similarities and differences in student outcomes in course content knowledge and agency across different SL sites. For example, does a student who is engaged in a project related to biodiversity and invasive species have higher increases in content knowledge in these areas? Does interaction with the community partner and project tasks impact agency? The purpose of this research question was to gain insight into what type and scope of SL projects results in the greatest growth in content knowledge and agency development.

Overall, both the qualitative and quantitative findings showed that students experienced growth in course content knowledge and agency through participation and the two were closely correlated. However, data showed that student growth in course content and agency did not differ across SL sites. Students experienced the same amount of growth regardless of project. These findings are discussed in greater detail below.

Research Question One: SL Impacts to Course Content and Agency

The quantitative and qualitative findings from research question one are discussed below. Course content findings are discussed first, followed by agency findings. Correlations between agency and content are discussed at the end.

In the fall of 2018 semester of 2018, the environmental science course used in this study had 87 enrolled students, with N=67 signing the consent to participate in the study. Students who opted to complete a research paper in lieu of the service project and students who were absent or opted not to participate during the consenting process were not included in the data. The findings of the study are described below. Outcomes related to course content are described first, followed by agency.

Quantitative: Course Content Knowledge

On the content knowledge assessment, students saw significant gains from pretest to posttest. Mean test performance is reported for each group in Table 4. 1

Table 4.1 Mean Test Performance (Standard Deviation) by Group

SL Group	Pretest	Posttest
Agriculture (N = 7)	20.00 (3.96)	25.57 (8.54)
Recycling (N = 9)	21.44 (6.02)	34.00 (5.83)
Land Use (N = 23)	20.43 (5.45)	28.17 (8.21)
Policy (N = 5)	19.80 (2.49)	30.20 (6.46)

The 2 (Pretest versus Posttest) x 4 (SL Groups: Agriculture, Recycling, Land Use, and Policy) ANOVA showed a significant difference between pretest and posttest overall content knowledge, $F(1, 40) = 58.05$, $p < .001$, partial eta squared = .59. There were no significant differences across the SL groups, $F(3, 40) = 1.74$, $p = .17$, partial eta squared = .12. The interaction was not significant, $F(3, 40) = 1.74$, $p = .17$, partial eta squared = .12. These results suggest that all students gained knowledge from pretest to posttest, and students in each SL group showed similar gains in knowledge across time.

It should also be noted that the number of student completing the posttest was much lower than the overall number of participants (N=44). This was due to the fact that when students took the Qualtrics survey, the researcher did not set-up the test settings correctly and many students in the class were unable to access it during class. The researcher was able to fix the settings after class, however not all students were able to complete the test on their own time.

Quantitative: Post-Service Survey Questions on Course Content

Student perceptions of course content gains confirmed the findings from the course content assessment and scores were also relatively high class-wide. Mean scores for all participants on the post-service survey course content questions was 8.2 out of 10 with a standard deviation of 1.7.

Qualitative: Reflection – Course Content

Overall, qualitative findings indicate that students experienced growth in course content knowledge after participation in SL. The majority of student reflection journals illustrated a medium to high level of course content rigor. Even though students with low agency scores were specifically chosen for the survey, it was difficult to find examples from the reflection journals of low rigor as defined in the analysis section of chapter three. The majority of student journals showed that students were able to make connections between course content and project tasks.

The excerpts from student reflections journals below illustrate a high-level of content rigor from each project category and show students making deep connections to the content, for example linking product life cycles to impacts on natural cycles:

Participant # 2: (Agriculture Project):

> I felt that the service-learning reiterated a lot of the ideas that we learned in class. We learned things like the importance of biodiversity, watering and

irrigation techniques, nitrogen cycles within the soil, and sustainable and organic agriculture. It was effective being able to have hands-on learning that allowed us to expand on our knowledge and learn some of the concepts that were introduced to us. For example, when David and I were harvesting some of the produce, I asked him why he preferred drip irrigation and he told me that it was the most effective and environmentally sustainable way to irrigate, which was reinforced to us later on in the course.

Participant #:56 (Land Use Project):

Learning about it in class is one thing, but then physically going out and doing the action helps to instill it in your brain. I learned from orientation, discussions at the beginning of the project, and other team members spreading their knowledge to me. I feel this was effective because I was able to physically see what was talked about in class. A specific example would be the invasive species, cheatgrass. We learned a lot about this plant and how it heightens fire levels while taking over and being stronger than the native species in the area. This related to my service learning because they taught us very similar information and we were then able to help by planting more native species.

Participant # 3 (Recycling Project):

This service learning experience was heavily related to human waste, and really helped bring that aspect of the class to life. I understand a lot more about waste, reuse, reusable materials, recyclables, changing your lifestyle to reduce waste and so on as a result of this service experience. Furthermore, this experience increased the understanding of the lifecycle of items humans use and

> how that impacts other natural cycles. For example, plastic in the ocean harming fish populations, which both harms them and their predators. A specific example of linking the course of the service was the river clean up, where we saw human's direct impact on an ecosystem.

In contrast, the excerpts below demonstrate a low level of content rigor and are generally limited in depth. No quotes from students from the recycling projects were included because all selected students in that project category demonstrated medium to high course content knowledge and made clear connections to course content. Below, participant 59 describes how project tasks were not well linked to the class and few connections were made on an academic level:

> Participant #59: (Land Use Project)
>
> I wish in the field on the project they went into it more. It is effective to get out the classroom and do a project because that's how you will retain the information better. But I would have to say I got that from the class not the service learning program.

Participant 33's description of the connections was more generalized rather than discussing specific course concepts:

> Participant # 33 (Agriculture Project)
>
> This related to class matters because it brought to my attention the throw-away society we live in and how much food is wasted in the United States because this relatively small garden feeds so many people and offers cooking classes with the food they grow and still has enough to give to the volunteers.

Overall, students had a relatively high level of content rigor and it was hard to find examples of low rigor. To gain more insight into how content growth was supported at the projects, the findings from the partner interview are discussed below.

Qualitative: Partner Interviews Findings

Partner interviews with four community partners representing all project categories reveal that student course content knowledge is well supported by their efforts at the project sites. Quotes below provide a more holistic picture of the phenomenon that were occurring.

Community partners responded to the following question in the interviews to gain specific insight into how course content was conveyed to students at the projects.

1. What scientific/environmental topics are covered in the project? How are these typically communicated with the students? Can you provide a specific example of a topic and how it is covered? Did students ever apply class topics to address the community issue? If so, can you share an example?

From this question, three main themes, relevance, interconnection, and accessibility, emerged and are discussed in detail below:

Relevance

The most common theme that emerged was the idea of relevance, with partners feeling that it was absolutely essential for students to understand the larger purpose of why they were doing SL project tasks and also how it related to their individual lives and the larger community. Especially given that most of the students in the project were non-science majors and that many of the project tasks were repetitive and physically demanding, partners felt it was especially important that academic content was explained in a way that communicated the larger purpose of their efforts.

All of the community partners indicated in the interviews that they integrated academic content into their field experience in both informal (e.g. answering student questions and discussing hands-on application on site) and formal (e.g. giving a Powerpoint presentation on these topics at the orientation) contexts. All partners emphasized that this was very important and helped students make connections between the work they were doing and the course content they were learning in class.

Partners felt that relevance needed to be communicated on both an individual and community level. Below the community partner from the recycling project described how she addressed individual relevance through the sometimes-monotonous task of picking up recycling:

> I try to get them thinking about how individual actions can add up cumulatively to really large impacts. The students get to see how, just one person having a soda and popcorn is not a huge amount of waste, but if 3000 people have a soda and popcorn, then that’s a lot of waste. And if people leave it in their seats, that’s a lot of effort for the people that pick up after them. It’s in one small sense learning about recycling and trash, and at a larger sense kind of thinking about individual responsibility and looking at patterns of behavior for large gatherings of people.

Other partners emphasized the importance of relating project tasks to a more holistic, big picture view of the issue:

> It's important to have someone there to tell them why: why we do what we do, why we weed, why we add compost, why we put the bark mulch down to suppress weeds. This garden is working all the time during the growing season so I think it's pretty cool for the fall semester that they are actually able to see plants finishing, developing and then harvesting them. They pick things off the vine that they saw when they were small.

<u>Interconnection</u>

Another key content theme that emerged from the partner interviews was interconnection, or in this context, being able to connect project tasks to larger themes, such as ecological systems and environmental challenges. Partners highlighted the importance of situating SL content/project tasks within a more holistic, systems-level view of the issue. Discussing the broader ecological impacts to the ecosystem, as well as connecting tasks to broader environmental challenges such as climate change and biodiversity loss was emphasized by all the partners.

An example that was shared was when partners from the land use category project had students re-plant sagebrush after a major wildfire. Below they explain the broader context of this task to their students in a broader ecological context:

> We'll talk about the fire cycle that we have now. We'll talk about invasive species and native plant communities and why it's important to have them and how they're functional and provide a source of food and shelter for wildlife versus if you just had non-natives. [We talk about] everything from pollinators to insects that break down the plant material because the native insects aren't there to break that down anymore. So, we talk about the whole function of the

> ecosystem and how that's impacted when you lose that native shrub component and why we need to put that back out.
>
> I talk a lot about native and non-native species because everyone recognizes cheat grass and everyone knows what a sage brush is, but I feel like people don't understand the scope of species diversity. It's biodiversity and healthy if in between the sagebrush you can see native forbs and grasses but when you look on to the foothills it's mostly a monoculture. It's all cheat grass. I think this project gives the students something they can take away when they go down a trail or help them understand why we're having hundred year fires every like, five years.
>
> Both of these quotes show how the partners explain the larger ecological connections of project tasks to the students. Rather than just explain how to plant sagebrush, they explain how doing this impacts other aspects of the ecosystem.

Accessibility

A final theme that emerged from several of the partner interviews was the need to make sure that the academic content they incorporated into their projects was accessible to students at all academic levels and also well-aligned to course curriculum. Two partners noted that they were unaware that students were non-science/environmental majors and therefore communicated academic content at a level that was inaccessible to students. One partner noted the she received blank stares from students when explaining plant genetics. After asking about the students' majors, she made adjustments to the way she presented project content so that it was more appropriately aligned with students' prior knowledge and course level. Partners expressed that being in close proximity to the students during the project also aided accessibility because they were able to field student questions. Moreover, partners felt that having knowledge and access to course content beforehand was especially helpful.

Partners emphasized the need to have access to the course syllabus and learning objectives before the project begins so that they can provide more appropriate and accessible content for students. One partner suggested that the instructor create specific prompts that specifically align with course content and another (see below) discussed creating specific educational goals for the SL partner based on the course content:

> We want to expand our goals beyond just, 'We want to plant things and we want to make things better,' to more educational goals for students that are aligned with class curriculum. So that everything's fluid.

Overall, when comparing the quantitative and qualitative findings on course content knowledge from research question, they clearly support each other. The findings from both methods showed that participation in SL increased course content knowledge and that this growth was significant. The findings from research question on regarding agency development are discussed below.

<u>Quantitative: Agency Pre/Post Survey</u>

To measure student agency development, students in each SL category completed a nine-question survey that measured agency before and after participation in the project. Mean test performance is reported for each SL category in Table 4. 1

Table 4.2 Mean Test Performance (Standard Deviation) by SL Site

SL Category	Pretest	Posttest
Agriculture (N = 9)	35.33 (6.30)	35.11(6.03)
Recycling (N = 7)	38.29 (4.23)	39.29 (2.69)
Land Use (N = 32)	33.47 (4.84)	35.59 (4.42)
Policy (N = 8)	36.13 (2.64)	35.88 (4.97)

I conducted a 2 (Pretest versus Posttest) x 4 (SL Groups: Agriculture, Recycling, Land Use, and Policy) ANOVA to examine change in agency from pretest to posttest across the four SL conditions. This analysis showed there were no significant differences from pretest to posttest, $F(1, 52) = 1.37$, $p = .25$, partial eta squared = .03. There were no significant differences across the SL groups, $F(3, 52) = 1.87$, $p = .15$, partial eta squared = .10. The interaction was not significant, $F(3, 52) = 1.66$, $p = .18$, partial eta squared = .09. These results suggest that agency did not differ across time or across SL conditions.

The small sample size may have made it difficult to detect differences. Also, because agency is difficult to measure before participation, it may be that the pre/post agency survey questions did not fully capture agency as well as the reflection journals or the post-service agency questions on the survey instrument. To test the relationship between coded reflection journals and pre/post survey scores, I scored the reflection journals of 13 students using the agency coding framework (see table 3.3) and correlated this score with the pre/post scores on the agency survey. Student journals were selected based on their agency score from the survey instrument described earlier. The correlation between agency from the reflections and agency from the pre/post survey ($r = .47$, $p = .20$). Thus, although these measures are moderately correlated, the correlations were not significant, which suggests the measures are not perfectly aligned and may not be measuring the same construct. Because no significant differences were seen from pretest to posttest, looking at the results of the post-service agency survey could likely provide more information about agency as it develops after participation.

Quantitative: Post-Service Agency Survey

The findings from the post-service agency survey showed a mean score for all participants ($N=56$) on this survey as 51.30 out 65 with a standard deviation of 8.51. Most scores in the course fell into the medium to high agency category, with very few in the low category (1-47 points). This indicates that overall, students seemed to have a relatively high level of agency after participation in SL. Qualitative data such as the coded reflection journals provided additional insight in the agency development during and after SL participation. To be sure that the reflection journals were aligned to the post-service agency survey questions, a bivariate correlation was run to compare the quantified reflection content scores with total post-service agency survey scores. The findings from this correlation showed a significant correlation between post-service agency survey scores and reflection scores. The reflection content was highly correlated with the survey results ($r = .854$, $p < .001$.). This indicated that the post-service agency survey instrument was well aligned with the reflection questions and therefore a reliable measure of student agency. Thus, it is appropriate to analyze the post-service agency survey as a measure of posttest agency. The findings from these journals are discussed below.

Qualitative: Reflection Journals

As discussed above, the pre/post agency scores did not show significant growth in agency over time. However, qualitative quotes from the reflection journals provided an in-depth explanation of how student agency was developed during the project and how students perceived it would affect them after participation. For this reason, the journals were likely a more effective way to measure agency.

In general, students with high agency during the projects spoke positively about the SL experience and identified specific things that contributed to their success (partner accessibility, choice, flexibility, passion, etc). Many discussed playing a significant role in the projects, and described how their role in the project not only influenced how the felt about the SL project, but also how SL translated to their own lives. Quotes have been divided into two categories, agency during the project and agency in the future. Examples of high agency during the projects from each category is listed below:

> Participant# 13 (Agriculture project):
>
> There were a number of tasks to complete as well as a big role of responsibilities that came along with each task. All the leaders and people in charge put a lot of trust in us to do what we were asked as well as do it the correct way and protect their garden. I was typically doing a job either by myself or with one other person, but we'd be in a group all in proximity of each other so we weren't isolated. The environment was super inviting and everyone was passionate about the garden, as well as the leaders were extremely helpful and nice when explaining what we should do and also let us take home the produce they grew!

Participant #56 (Land Use Project):

A highlight of my service learning was in Cascade, Idaho. I planted willows in the freezing cold for about five hours. This was extremely hard work, but very rewarding in the end. You definitely have to care for what you are doing to take on a task like this. The holes had to be about three feet deep which was quite exhausting physically. This is definitely a day I won't forgot and feel really proud about. I really enjoyed that they offered different projects because it kept the service learning fresh and exciting.

Participant # 20 (Land Use Project):

I honestly couldn't have asked for a better working environment. It was very individualistic, though you could always plant in groups with your friends. [The community partners] were always accessible to us as they were planting and working as well, so we could continuously check up on one another and help each other out as needed. They sent out many emails informing us of event dates and service opportunities.

Participant #1(Recycling Project):

A highlight of my service experience was the flexibility offered, there were many opportunities to volunteer and get involved more in depth with the project. This allowed me to find days and times that worked along with my school and work schedule and also to participate in the events that I was interested and wanting to volunteer for.

Students with low agency in the projects tended to report less positive experiences and often referred to the challenges they faced rather than successes (partner availability, tasks, monotony, etc.). Participant 14, for example, selected her SL project because she viewed it as the "easiest."

Participant #14 (Recycling Project):

Pre-Reflection: I picked this service project simply because it seemed to be the easiest one for me to get all my hours done for. I also was interested by this project because I myself love to go to concerts and events and am intrigued to see how much waste these events produce.

Post Reflection: The highlight of working with the BSU sustainability program was being able to watch the concerts that I volunteered at. The challenge of helping at these events was that there really was not much to do. The venue poured all drinks into clear plastic cups that were not recyclable so when making rounds from trash can to trash can there was not much for us volunteers to pull out. This affected our service experience because (at least for me) I felt that I was there for little to no reason.

Participants 56 and 59 both highlighted that lack of partner guidance and physical project tasks led to a decrease in overall agency at the project sites:

Participant #56 (Land Use Project):

When I did the planting in Cascade I was alone and ended up planting the first tree in the wrong location and having to redo it. I would have definitely liked a little more guidance because it would have been mutually beneficial. I would have more knowledge on the subject and they would be able to help me give better results for their company and the environment. Besides a talk in the beginning with a little direction, the community partner didn’t help as much as I would have liked.

Participant #59 (Land Use Project):

I did face a few challenges doing my time such as workload. I had to do lots of work for the service learning organization I chose. I never really thought it to be like that. Mentally I wasn't prepared but I just stuck to it because I needed the hours and I did not want to be looked at as the weak link on the team. The activities that I did was planting plants. For this one my role was to dig holes but I also chose to plant some plants too as my group members needed help. Another activity that I did was trail restoration. My responsibility for this was to go on the trail and pick all the weeds. Then later on they changed their minds and we ended up pulling weeds on the whole hill. I mostly worked in groups and often times I rarely saw the partners because they were off doing something else or helping another group.

Students with high scores in future agency typically discussed how participation impacted them as an individual and the actions they will take in the future in light of the SL experience. They also discussed future plans for volunteering for in environmental issues.

Participant #2 (Agriculture Project):

Throughout the service learning project, I set up a compost pile at my own house, I try to eat as minimal amount of meat as possible, and I have even started my own garden at my parent's house. I use many of techniques that David taught us to be able to grow my own food in a more environmentally friendly way. I feel as though it is making me a much happier and healthier individual by giving me more energy, allowing me to learn how to cook, and most importantly how to spread this important information to others.

Participant #56 (Land Use Project):

I do feel like I can make a difference in the future. This class has opened my eyes up so much and has made me want to take action. I bring what I have learned in this class to real life by telling my family and friends about how their actions have an impact on the environment. I have talked about it so much that I already see a change in their behavior. They are doing things such as planting their own food, not using plastic, and caring for the environment even more. I do also plan to continue volunteering for Fish & Game as well as other organizations because I really enjoyed seeing the result from my hard work. I felt that I was making a difference and helping the environment as well as my community. My opinions about environmental issues/science have changed through this service-learning experience. I saw how deeply the other volunteers and workers cared for what they were doing and it really hit my heart. Learning about the issues also made me aware of things that would have never crossed my mind otherwise. I now have more knowledge that I can take and spread to others to take action. I am really grateful for this awesome hands-on experience!

Participant #1: (Recycling Project):

After volunteering for the BSU sustainability project I feel motivated to keep participating in service learning opportunities. I think a significant and positive difference can be made on our environment. All starts by become aware of the environmental problems that can be created or heavily influenced for some human behaviors. Then we can contribute to spread awareness in our community and to take a leadership role. Being involved in this project definitely helped me to take that leadership role as well as strengthen my ability to do team work.

Students with low agency scores on the framework expressed that they felt they had limited impact on the long-term goals of the projects. They also indicated limited interest in volunteering in the future:

> Participant #33 (Agriculture Project):
>
> I do not feel like I can personally make a difference in this issue for more than just myself because I don't think I learned enough about the crops for the seasons or how to plant new crops.

> Participant #14 (Recycling Project):
>
> Although seeing the Taco Bell Arena after huge events and all the trash that is left by people in the stands was impactful to me, as someone who also enjoys events such as concerts, the actual work that I did in this project was not as impactful as I had hoped. I don't think this project was effective in opening my eyes to the huge problem that human waste is.

An analysis of student reflection journals showed that overall, students had medium to high levels of agency following SL participation and that participation was largely a positive experience for students. Students discussed many aspects in the journals that positively contributed to agency development, such as ability to engage in meaningful and challenging tasks and access to the community partner. Overall, it was difficult to find student journals with low levels of agency and in some projects, such as the agriculture project, there were no low agency scores to pull quotes from at all. Partner interviews were anal provided insight into why students had relatively high agency overall.

Qualitative: Partner Interviews - Agency

Community partner interviews were conducted to compliment the data and to give their perspectives on student experiences and agency development. Themes that specifically impacted agency development are discussed below. The four key parent themes that related to agency development were communication, connection, project design, and self-efficacy. These themes, as well as the child subthemes that connected to each parent theme, are discussed in detail below.

Communication

Overall, the most prominent theme that emerged and was reiterated throughout the interviews was communication, both with regard to clarity of student expectations and the importance of fostering interpersonal connections. Four major subthemes emerged from the communication category: clarity of expectations, interpersonal relationships, partner enthusiasm, and communication of the greater purpose of the project to students.

All SL partners emphasized that need for clear and frequent communication with the students and believed that it positively impacted student connection and commitment to the projects. Partners discussed the need for frequent communication with students through a variety of channels (e.g. email, spreadsheets, texts, in-person reminders, etc.) as well as setting clear expectations and accountability with the students. Partners emphasized the importance of relaying to the students that they were accountable to the agency they were serving, which included following rules, and meeting expectations for attendance and participation. Several projects noted that they made changes from previous semesters to increase communication and also to make their expectations and time requirements even more clear to students at the orientation session. One partner described how a breakdown in communication created some challenges in her project. She hired student interns to oversee student recycling at some of the concerts, but since the interns lacked confidence and were not well trained on how to manage student volunteers, some SL students violated policy rules and were also less on-task.

Interpersonal communication was also something that all partners addressed in the interviews as being critical to student engagement and investment in the projects. Below community partners from different projects discussed how they approached interpersonal communication:

> At the projects, I'm working in and amongst the BSU students. I try to spend a lot of time with them and make sure I get to know a little bit about them. I enjoy putting a face to a name and learning what they do outside of helping us and how is school going them.
>
> I try really hard to be personable with them and really get to know them and see what's going on with their lives. My level of enthusiasm and interest I think has a lot to do with student's engagement level and also my effort to get to know them on a personal level. So the students that did really well, I know quite a bit about them.

Several partners described how they felt their communication style and level of enthusiasm directly impacted student engagement and motivation. Some partners also emphasized the importance of communicating their gratitude and appreciation for student efforts.

> I think enthusiasm breeds enthusiasm and so it's important to have someone there that is excited about gardening and who can share how grateful we are for them. I think it is helpful for them to know, like you're actually making a difference. Like this might not seem all that exciting at times but you are helping us move this process faster or turn soil faster, turn the garden fast so that we can really do what we do best which is to educate.

Communicating the larger purpose of the project tasks to students was also viewed as critically important to student motivation and a successful project. All partners mentioned that they encouraged students to continue to volunteer with their projects in the future and kept them informed of future opportunities through email throughout the project and beyond.

<u>Connection</u>

The theme of connection was a strong theme of the interviews and tied well to the communication. The key subthemes that emerged from in the interviews for connection were building relationships/community among volunteers and the importance of connecting students to the greater mission and purpose of the project.

Building upon the idea of interpersonal communication from above, many partners viewed SL as a tool for building connections and relationships with their agency and with other students in the project, and that this sense of connection to others enhanced the experience and engagement level of students overall. A strong connection to the community partner, to other students in the project, and to the larger community by serving alongside other adult volunteers increased this sense of connection and investment to the SL project. Fostering a team atmosphere was noted as critical to this process by several partners. A community partner from the agriculture project described below how connections were fostered in her project through a blend of clear communication, strategic scheduling, and an emphasis on relationship building:

> We asked them to come for a three-hour block of time so that they can develop a relationship with the people they're working with in community. You can't really get into a good workflow in like one hour. We really want them to be invested and learn more about the project at hand for that day. This way the students are accountable, we know exactly when they're coming in and we can really make a plan to make their experience the most rewarding and just reap the most rewards and connections during that time. In the past, it would be like, 'you can come in for this day, okay, we'll make it work but you're probably hoping to be alone and you're probably just going to be working on this task.' It would just prevent true connections from happening.

Partners also emphasized that importance of getting students to make personal connections to project and to understand how project tasks related to the mission of the agency and also benefitted the community at large, as seen in the quote below by a land use project partner who connected wildlife to livelihoods:

> After the Table Rock fire, people are starting to realize if we don't do anything about this, our homes could burn. So it isn't just about rangeland or you

> know, conserving wilderness. This is about our livelihoods. And I think driving the point home that this directly impacts your quality of life in the valley, and that what you're doing has a positive impact for everyone else that you live with. Kind of making it a bit personal, maybe explaining it like, this if your responsibility as a citizen to do your part.

Fostering a personal connection to the experience really helped the students to see how their connection to these projects.

<u>Project Design</u>

Project design was emphasized by all SL partners as being critical to the success of their projects. The key subthemes in this category were time/scheduling, flexibility, and engaging tasks. Time and scheduling was emphasized by all the partners and something that many projects have made adjustments to over time after facing challenges with getting students to complete hours due to conflicts with their work/school schedules. SL projects took different approaches to adjusting scheduling to best accommodate student needs, ranging from offering a variety of times and options for students to scheduling projects with fewer options but larger chunks of time. A partner from the campus sustainability project discussed her approach below, which include awareness of student needs and offering a variety of times to serve:

> My project is designed to be intentionally variable because I get that students work and have class and especially work. They have a lot of responsibilities so I tried to do a series of shorter events, like three hours or less, with opportunities to also do longer events like six or seven hours. I try to give them enough opportunities to get a chunk of hours at a time.

Building upon the idea of scheduling, some partners emphasized the value of flexibility and choice in project design. Some partners felt that students were more motivated and invested when they were given many options for times to serve and also a variety of project tasks that exposed them to different aspects of the project. Some partners mentioned that they also provided flexibility for students by letting them choose whether they wanted to work in groups or alone, depending upon their work style, as well as provided more challenging project tasks for experienced students such as leading a group of students on planting activity. Finally, providing transportation to the project site, whenever possible, or creating carpool teams was something that partners felt significantly increased student accountability and engagement.

One of the SL partners, whose project was set at an educational garden, had faced many challenges with student accountability and engagement in previous semesters. As a result, she made significant changes to the project design in the above areas and saw positive results. In the interview, she emphasized the importance of thinking holistically about project design and to build a volunteer culture that centers around adapting to student needs:

> I think the student in today's college experience is just really busy and that they have full time jobs, part time jobs. They're just trying to do the best they can while still getting some money here and there. So it's hard when they have a lot of pressure on them. I think we need to do our best to really engage them and spark their curiosity in whatever way we can to that, either by asking questions or just getting to know them… it's really important. I'm really trying to create a volunteer culture at the organization.

Understanding the needs of students was viewed as critical to getting students to attend and complete their service hours. SL also partners emphasized that engagement was best fostered when project tasks were meaningful to students. Often project tasks such as digging holes, weeding, and picking up recycling can be monotonous for students, but if these activities are balanced with other more engaging tasks like harvest festivals and community planting events, partners noted that students generally feel more motivated. The campus recycling project, for example has students pull out recycling out of trash cans during events. While this might not seem like the most meaningful activity for students, the community partner keeps students engaged in the task by also having them track data of what they are pulling out and communicating to them that she will be using this data for a research project for the university.

<u>Self-Efficacy</u>

A final key theme that emerged from the interviews was providing opportunities for students to exhibit self-efficacy, a key component of agency development. The subthemes that emerged from this category were leadership, reciprocity, advocacy, and skill development. All of the partners felt that it was important to provide opportunities for experienced or highly engaged students to take a leadership role in the role in their projects. These opportunities ranged from a student serving as the leader for a group of other SL students to students taking on their own individual project as was described below by both the land use and agriculture projects:

> I've said, 'if you guys are interested in helping in a specific way or if there's a trail or a project that lies close to your heart, let me know.' I had a

> student who wanted to make the foothills more accessible to Spanish speakers so she translated my Powerpoint into Spanish for the Open Spaces website.
>
> I think one of the beautiful things about having service-learning students is that they all bring different skills to the table. We had one student who wanted to write informational cards and did some drawings for use about different weeds that that we could use them to educate new volunteers.

Another way to foster self-efficacy in science that was noted by the partners was allowing students space to ask questions about the new experiences and knowledge they were gaining. All partners shared that it was very important for students to be able to ask questions as they worked and for them to have opportunities to share their own experiences and knowledge with the project partner. Creating reciprocity, where students were free to dialogue, ask questions, and contribute knowledge was discussed as a critically important aspect of fostering self-efficacy and student investment as seen below:

> The students like to teach us things too and they're free to. It's a mark of an engaged student, their willingness to share. One of our students was sharing how her family will boil pumpkin leaves and squash leaves and eat them and we were like, 'we never knew that!'

Some partners discussed that advocacy played a role in their SL projects and that students seemed very motivated by this. For example, students in the campus sustainability project noticed that concessionaires at the concerts were throwing recyclables into the trash cans so they spent time educating and dialoguing with concessions employees about the importance of recycling and how to do it. After this dialogue, everyone ended up getting on board with recycling and worked collaboratively in the effort. In the gardening project, students were able to share the knowledge the gained at the garden with local families that visited the garden during a harvest festival. Student volunteers taught younger children about planting and dialogued with local families in the area about the how to grow their own food.

Finally, several partners highlighted the value of SL to skill development for students. Students gained a range of valuable long-term life skills from participation, such as how to plant, compost, grow their own food, cook from the garden, identify weeds, recycle at their homes, and minimize personal waste.

Overall, the findings from the partner interview showed that all of the SL projects linked to this class had partners that created and designed their projects with a great deal of student agency in mind. For example, project designs from the sites revealed scheduling and communication strategies that were designed to support student needs by adjusting scheduling, providing avenues for students to take on leadership roles and engage in meaningful tasks, and fostering a culture of support and teamwork.

Correlations: Agency and Course Content

Research question one included a sub question that measured the correlation between course content knowledge and agency. To measure this, the total score from the agency post-service questions was correlated with change in pre/post content knowledge assessment. According to this correlation, change in course content knowledge was significantly correlated with agency ($r = .37$, $p = .02$). Therefore, the finding shows that students with high course content knowledge also tended to have high agency. That is, agency was related to learning of content.

In summary, when quantitative and qualitative findings were compared, there were some differences. The results of the pre/post agency survey did not show any significant growth of agency after participation. However, the post-service agency survey questions, which were correlated with the qualitative reflection journals, did show that students overall had relatively high mean level of agency after participation. Qualitative reflection journals showed examples of high and low agency among the students and examples of high agency were much more abundant than low. In some projects, low agency examples did not exist. Finally, partner interviews revealed that the SL projects linked to this study all incorporated strong elements into their project designs to support the development of student agency, such as clear communication strategies, flexible scheduling, and meaningful tasks that were connected to a larger purpose.

Research Question Two: Differences Across SL Sites

For research question two, the quantitative and qualitative findings are discussed below. Course content impacts are discussed first, followed by agency.

Quantitative: Course Content Knowledge

The purpose of research question two was to assess if there were any significant differences in course content knowledge and agency development across SL project sites. To assess this, the course content pre/post-test included thirty questions that were aligned to match the activities and knowledge associated with each the three SL project categories (ten questions per SL category). Students in the policy project were included in the analysis to increase the total N for the study.

Table 4.3 Mean Test Performance (Standard Deviation) by Group on Agriculture Questions

SL Group	Ag Pre	Ag Post
Agriculture (N = 7)	4.57 (1.51)	5.71(2.69)
Recycling (N = 9)	5.89 (2.315)	8.78 (.833)
Land Use (N = 23)	5.00 (2.05)	6.26 (2.45)
Policy (N = 5)	4.20 (1.30)	7.00 (1.87)

I used a 2 (PREPOST) x 4 (SL Groups: Agriculture, Recycling, Land Use, Policy) ANOVA to compare pre/post course content on SL project-specific questions by SL Groups (Agriculture, Recycling, Land Use, and Policy). This analysis showed a significant difference in performance across pretest and posttest, $F(1, 40) = 19.87$, $p < .001$, partial eta squared = .33. As seen in Table 4.3, posttest scores were higher than pretest scores. The PrePost * SLCOND interaction was not significant, $F(3, 40) = 1.27$, $p = .30$, partial eta squared = .09. Test performance differed across the SLCOND, $F(3, 40) = 3.01$, $p = .04$, partial eta squared = .18. Post Hoc tests showed SLCOND 1 (Agriculture) is marginally less than SLCOND2 (Recycling), $p < .10$. SLCOND 2 (Recycling) is marginally greater than SLCOND 3 (Land Use). Although it is surprising that the recycling SL project scored higher on agriculture questions, this may be due to this group starting the course with more knowledge of agriculture (see the higher scores on the pretest).

The same tests were run for the recycling question category and the land use question category. To foreshadow, performance on these questions showed significant gains from pretests to posttest, but no differences across SL conditions

Table 4.4 Mean Test Performance (Standard Deviation) by Group on Recycling Questions

SL Group	Recycling Pre	Recycling Post
Agriculture (N = 7)	5.43 (2.07)	6.29 (2.43)
Recycling (N = 9)	5.11 (2.15)	8.22 (1.86)
Land Use (N = 23)	5.22 (1.88)	7.13 (2.24)
Policy (N = 5)	6.20 (.447)	7.60 (1.67)

The 2 x 4 ANOVA showed a significant difference in performance across pretest and posttest, $F(1, 40) = 58.06$, $p < .001$, partial eta squared = .59. As seen in Table 4.4, posttest scores were higher than pretest scores. The PrePost * SLCOND interaction was not significant, $F(3, 40) = 1.7$, $p = .17$, partial eta squared = .12. Test performance did not differ across the SLCOND, F(3, 40) = 1.6, p = .21, partial eta squared = .11.

Table 4.5 Mean Test Performance (Standard Deviation) by Group on Land Use Questions

SL Group	Ag Pre	Ag Post
Agriculture (N = 7)	4.14 (1.22)	5.57 (2.44)
Recycling (N = 9)	4.56 (1.59)	8.00 (1.87)
Land Use (N = 23)	4.57 (1.41)	6.74 (2.12)
Policy (N = 5)	3.80 (1.30)	6.00 (2.12)

The 2 x 4 ANOVA showed a significant difference in performance across pretest and posttest, $F(1, 40) = 41.91$, $p < .001$, partial eta squared = .51. As seen in Table 4.5, posttest scores were higher than pretest scores. The PrePost * SLCOND interaction was not significant, $F(3, 40) = 2.92$, $p = .25$, partial eta squared = .096. Test performance did not differ across the SLCOND, $F(3, 40) = 5.2$, $p = .67$, partial eta squared = .04.

Overall, the results showed there were no significant differences in course content knowledge scores based on SL group. SL group does not have an effect on test performance.

Quantitative: Agency Survey

The pre/post agency survey also showed no significant differences in agency development. Data from the post-service agency survey was used instead to measure differences in agency by SL group.

Table 4.6 Mean Agency Scores (Standard Deviation) by Group

SL Group	Agency Scores
Agriculture (N = 9)	49.56 (11.48)
Recycling (N = 7)	56.29 (4.57)
Land Use (N = 32)	51.56 (5.96)
Policy (N = 8)	47.88 (14.14)

I conducted a 1 (Post-service Agency Survey Score) x 4 (SL Groups: Agriculture, Recycling, Land Use, and Policy) ANOVA to compare scores from the post-service agency survey scores by project site. There were no differences across the SL conditions, $F(3, 52) = 1.40$, $p = .25$, partial eta squared = .08.

Qualitative: Reflection Journals and Partner Interviews

Overall, the themes that emerged from both student reflection journals and partner interviews were very consistent regardless of SL project and confirmed the quantitative findings. An analysis of partner interviews revealed that all SL partners were highly committed to student success and incorporated SL best practices into their project design. Moreover, all SL projects in the study were well-aligned to course content. Because of this close alignment and use of best practices, there were no notable differences across projects.

Overall, the quantitative and qualitative findings from research question two confirm each other. Both methods show no significant differences across SL sites in course content knowledge and agency growth. While students from all projects had significant growth in content knowledge and agency overall, the type of project they were enrolled in seemed to have no effect upon this growth.

The following chapter provides a discussion of the findings and how they relate to the literature, and also addresses the implications of these findings, the limitations of the study, recommendations for future research, and conclusions.

CHAPTER 5: DISCUSSION, IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

The primary purpose of this mixed-methods case study was to more adequately assess the outcomes that were linked with participation in a SL projects in an introductory environmental science course at a mid-sized, urban university. The goal of the study was to gain insight into the role that SL can play in STEM courses and to help identify best practices moving forward. More specifically, this research used a case study model that assessed student outcomes (course content knowledge and agency) in SL projects and drew general conclusions about the what types of SL projects were most effective at fostering these outcomes. The study also analyzed whether there were any correlations between course content knowledge and agency. This research will contribute to the increasing body of literature in the SL and STEM fields. It will also help practitioners and researchers alike consider the ways in which participation in SL can impact student agency and build course content knowledge, since both have the potential to increase access to STEM, build scientific literacy, and encourage persistence in STEM courses. This chapter begins with a discussion and interpretation of the study findings and how they link to literature in the field. I then discuss the implications of these findings to the field and discuss the limitations of this study. The chapter concludes with recommendations for future research and final conclusions.

Summary and Interpretation of Findings

A summary of the quantitative and qualitative findings are discussed in the section below. The findings from research question one are first discussed, followed by research question two.

Research Question One: SL Impact on Course Content and Agency

Research question one in this study asked, "How does participation in service-learning, in an introductory environmental science course, impact overall course content knowledge and agency?" A sub-question asked, "What, if any, is the correlation between course content knowledge and agency development?" A discussion of the quantitative and qualitative findings used in the study are described below. Impacts to course content are discussed first, followed by agency.

Course Content

Quantitative findings from research question one found that students across the board had significant gains in course content knowledge. Scores on the pre/post content knowledge assessment showed that students scored significantly higher on the posttest than the pretest. In addition, students also had relatively high mean score (8.2 out of 10) on the two content questions asked on the post-service agency survey instrument. These findings indicate that students gained course content knowledge across the board after taking the course and participating in SL.

Qualitative findings from student reflection journals confirmed the qualitative findings and showed that students in the course had a relatively high level of content rigor overall. In some SL project categories, such as recycling, it was difficult to find any students whose journals exhibited low course content growth. Coded student reflection journals showed that the majority of the students in the course scored in the medium to high agency category, and were able to make connections between SL and specific course concepts, for example identifying how composting improved soil conditions. Many students were also able to make deeper connections between course concepts, for example being able to link the nitrogen cycle to the fertility of certain crops or explaining how invasive species impacted insect biodiversity. Finally, in many student journals, connections were drawn between course content and the larger scientific issues the students were addressing at the project sites, for example the role of wildfire and its impact upon local air quality.

Partner interviews revealed that many students entered their projects with very little scientific background knowledge of the issues they were addressing, so it is surprising that students had significant gains in growth in content knowledge. However, analysis of partner interviews revealed that a large emphasis was placed upon educating students about the larger purpose of project tasks and explaining the ecological connections related to the work they were engaged in. The themes of relevance, interconnection of scientific concepts, and accessibility of course content (e.g. explaining concepts in a way that was accessible and interesting to students and also being available to field students' questions) were noted as critical elements by all the SL project partners. Moreover, in this study, course content was well-aligned with the SL projects and partners were given course learning objectives and the course syllabus ahead of time. The partners and instructor were in regular communication and students were asked to reflect about their experiences on several different occasions and formats throughout the semester, including a research project and team reflection poster. For this reason, it is not surprising that course content knowledge was enhanced through SL participation. Students in the study were clearly engaging with all parts of the ELT cycle, reflecting upon SL project tasks in class, applying them to abstract course concepts, and then considering how these tasks apply to the larger community.

Overall, these findings are not well supported by SL STEM literature and indeed, lack of course content rigor in SL has been one of the main concerns addressed by STEM faculty (Brubaker & Ostroff, 2000). Previous literature in SL STEM, though limited, has indicated that in many studies, SL participation did not lead to significant gains in content knowledge, or if there were gains, that it was hard to disassociate learning that occurred in class from learning that occurred at the SL site. Hayford et al.'s, (2015) literature review of SL STEM revealed that in many of these studies, the SL component was not well-integrated and was limited in scope (three-six hours in total) (Cawthorn et al., 2011; Leege & Cawthorn, 2008; Packer, 2009; Kennell, 2000; Ng & Ling Ling, 2012). In this study, however, the projects were much more comprehensive in length (15 hours), included regular communication with community partners, and were well-integrated into the class assignments and reflection exercises.

Other more recent literature in SL STEM, however, has shown that SL can lead to significant gains in content acquisition and that the more comprehensive and integrated the project, the more effect SL seems to have on student achievement. Tawfik et al. (2014), integrated PBL into a non-majors Biology course and found modest to significant gains in student achievement after SL participation. The SL project was well-integrated with course concepts and required 10 hours of service, in addition to the completion of a comprehensive group project. Daniels et al. (2015) studied the effects of a RSL project, in which students conducted research about their SL projects in addition to serving hours. This SL project was very in-depth and engaged students in the research, design, and implementation of the project over the course of an entire semester. Results from this study results show that students experienced significant academic growth in content knowledge. Although it is very difficult to disassociate student learning that occurred at SL project from the classroom environment, qualitative journals from this study did indicate that hands-on application of course concepts at the SL sites helped students to gain a better understanding of content. The literature examples described above support the findings of this study and illustrate that for course content gains to be significant, the SL project must be well-integrated into the class and have a holistic, comprehensive design. This study showed that participation in SL, when well-aligned to course content and comprehensive in design, can help students make connections and foster content knowledge growth.

Agency

Student agency was measured quantitatively through a pre/post agency survey. The quantitative findings from this study showed that student agency levels did not significantly change from pretest to posttest. Participation in SL did not result in significant changes in agency level. However, this is likely because it is very difficult to assess agency about something students have yet to experience. Questions on the pre/post survey instrument did not ask about the SL participation specifically because students had not participated in the projects before taking the pretest.

A more accurate measure of agency growth, in the context of this study, were the findings from the post-service agency survey questions and coded student reflection journals. The mean score from the post-service agency survey was 51.3 out of 65, with very few students in the course scoring in the low agency category (1-47 points). The questions from this survey specifically asked students about their experiences in the SL project and how they planned to apply it to their lives in the future. To make sure the survey was an adequate measure of student agency, post-service survey scores were correlated with scores from the coded student reflection journals and found to be significantly correlated, which indicated that the reflection journal data were well-aligned with the questions on the survey instrument, and therefore both were accurate measures of student agency in the projects.

A qualitative analysis of the student reflection journals confirmed the findings from the survey instrument and found that SL participation resulted in medium to high levels overall. It was difficult to find examples of low agency in the reflection journals for most of the projects and none could be found for the recycling category. Most students in the course noted that SL was a positive experience for them and highlighted things such as close interaction with the community partner, ability to ask questions, engaging in challenging tasks, working in a team atmosphere, and feeling like they were making a difference as key factors that increased their agency in the projects and beyond. One student, for example, described how completing a challenging task that she did not believe she could accomplish was very empowering. Another student described how teaching others at a community event how to grow a garden gave her confidence in her abilities and also helped her see the value and relevance of project tasks.

Partner interviews also confirmed these findings and showed that the SL projects in this study did an excellent job of incorporating many elements into their project designs that helped foster student agency. Building interpersonal connections to students, applying tasks to daily life, creating a team atmosphere, incorporating flexibility and leadership opportunities, and giving students opportunities to build new skills and serve as advocates for the projects, were all aspects that helped students build agency not only at the project but beyond. The themes of interpersonal communication, connection to the projects and to other participants, relevance to daily life, and self-efficacy, such as leadership and advocacy, were the most prominent themes that emerged and aligned well with the definition of agency in this project. Given that all SL projects incorporated agency fostering elements into their design, it is not surprising that agency was positively impacted in this study.

To date there is no literature in the field of SL STEM that has explicitly explored the idea of agency however, some literature has assessed SL's link to self-efficacy, personal development, and citizenship and found that gains in these areas after SL participation (Eyler & Giles, 1999; Dukhan et al. 2008, Felzien & Salem, 2008; Yeh, 2010). Because no literature explicitly aligns with this study, it is difficult to relate the findings to previous literature. However, previous studies have highlighted that SL participation led to gains in leadership skills, self-efficacy, and access to social and cultural capital, all of which are linked to agency development, and many of which were described by students and partners alike in the qualitative data. Daniels et al. (2015), for example, studied the effects of RSL on health majors and found that SL had tremendously positive results, which included growth in social capital (connections within the community and with peers and faculty alike), self-efficacy, and leadership skills. Yeh (2010) also found that SL participation led to gains in social and cultural capital and self-efficacy as students gained knowledge of community and university resources and had increased opportunities to dialogue with their professors and peers about university culture through the projects. Students in this study also noted in reflection journals that the ability to ask questions and dialogue with others at the projects helped them feel more successful and that engaging in meaningful and challenging tasks, as well as the ability to share their knowledge with others, were very empowering and helped them to change their perception of the issue.

Correlations

Finally, findings from research one sub-question, “What, if any, is the correlation between course content knowledge and agency development?” found that pre/post content assessment scores were significantly correlated with post-service agency survey scores. Students with high course content scores also had high levels of agency at the end of the course. This indicates that SL courses that emphasize course content growth may also see increases in student agency and vice versa. This confirms previous literature in SL that describes the broad range of positive outcomes that can emerge from SL participation (Eyler & Giles, 1999), and shows that SL has the ability to increase content knowledge, while also fostering student agency, both of which could increase access to STEM and build scientific literacy. This is a very important finding, as it highlights that SL projects can help students build agency in STEM and, as a result, may also increase their interest in and knowledge of course content.

It is difficult to assess from the findings of this study, however, how these outcomes interacted with one another, or if one caused the other to occur. For example, did students who came to into the course with high academic skills naturally have high levels of agency? Or did participation in the SL projects increase student agency and subsequently help build academic knowledge? Findings from the qualitative journals seem to indicate both to be true. Students with high pretest content scores generally tended to have high agency in the projects. But many students with low pretest scores also had high agency scores after participation. Many of these students described in their journals that understanding the overall relevance of the SL projects to their local communities and learning in a hands-on context sparked their interest in the project tasks and helped them to better understand course content.

Research Question Two: Differences Across SL Sites

The second research question in this study asked, “How do course content knowledge and agency development differ across SL sites?” The rationale for adding this research question was that as the instructor for the course for the past six years, I have had many different SL projects connected to the class and some have seemed to be better than others at fostering agency and course content growth within my students. Given this, it was hypothesized that different types of SL projects would result in differences in student agency and course content. However, the quantitative analysis in this study showed no significant differences in student agency or course content knowledge across SL sites. Qualitative analysis of coded interviews and reflection journals also showed no major differences in student’s level of agency or content knowledge by SL project. In this study, the type of SL project that students were participating in did not seem to affect course content growth or agency development, however, students did experience gains in both course content and agency (on the post-service survey) overall regardless of the project they were in.

To better assess the phenomenon that were occurring at project sites and see why there were no significant differences between sites, qualitative quotes from student reflection journals, as well as community partner interviews, were analyzed. Student reflection journals and partner interviews revealed that all of the partners interviewed in this study had supportive project environments that integrated course content into project tasks and fostered student agency development by providing clear communication, explaining the greater purpose/relevance of project tasks, and helping students build self-efficacy by offering leadership and advocacy opportunities.

Eyler and Giles (1999) foundational book, “Where’s the Learning in Service-Learning” outlines best practices for SL practitioners in higher education. Their findings are based upon two national research projects on SL that they conducted that included over 1500 students and 20 colleges and universities that had adopted SL. From this research, they identified best practices for the design of SL projects. These best practices included, “high quality placements that afford students the opportunity to engage in meaningful work, have important responsibilities, take on challenging and varied tasks, work directly with community partners, receive support and feedback from the partner staff, and be completed over a sustained, more-long term period” (p. 190). Eyler and Giles also found that student outcomes were heavily influenced by SL program design, which can be enhanced by incorporating application of course content to the field, exposing students to a diversity of perspectives, and providing adequate opportunities for written and oral reflection (p. 170-171, 177).

An analysis of the partner interviews from this study showed that all of the SL projects linked to this class implemented the best practices outlined by Eyler and Giles in their projects. For example, all projects noted the importance of close partner interaction with students and the necessity of offering a variety of meaningful project tasks. Indeed, this finding was further confirmed by site visits to the projects, where I was able to see the partners working in action with the students. Partners from the gardening category were planting alongside students and partners at the land use project provided careful instructions and oversight of sagebrush plantings.

Moreover, the SL projects in this study had been connected to the course for several semesters and were not only well-aligned to course content, but had also gone through several iterations of project re-design to best meet the needs of students. A specific example of this is the gardening project, which for many semesters struggled to get students to complete their hours in a timely manner. Students in this project often reported that they worked alone at the project site, sometimes weeding for several hours at a time without interaction from the community partner or other students. After receiving this feedback, the instructor worked closely with the community partner and the university SL office to help the partner re-configure their project to include increased partner interaction, opportunities for students to learn more about the purpose of the project, a range of project tasks, and a restructuring of scheduling so that students could complete their time in large chunks working alongside other students. Since the re-design, the project has seen an increase in student engagement levels and a decrease in attendance issues.

Given that the projects were well-aligned with SL best practices and provided a high-quality service experience to the students, it is not surprising that there were not significant differences in the projects. Indeed, students' reflection journals also reveal that best practices such as close partner interaction, ability to ask questions, and the ability to engage in meaningful, relevant, and challenging tasks helped them to be successful in the projects, to make connections to course concepts, and to want to continue to volunteer in the future.

This data is also supported by more recent literature in the SL field. It has been noted that projects that offer SL in a limited time frame (three-six hours), with limited connection to the class content, do not lead to student outcomes. The more comprehensive the project, such as the research described above in which RSL and PBL were incorporated into the projects, the more positive the outcomes seem to be for students participating in SL.

Implications of Findings

Overall the results of this study show that incorporation of an SL component into an introductory level science course can help foster growth in both course content knowledge and agency development. Moreover, the findings show that course content knowledge and agency are closely correlated and that students who had high levels agency in the SL projects, also had high levels of course content knowledge. This illustrates that when course content knowledge is aligned to SL projects tasks and is well-integrated into the both the SL projects and classroom, student agency is also likely to increase.

The findings of this study also showed that course content knowledge was not compromised by SL, and actually may have led to gains in course content acquisition. Although the findings did not show that content gains were specifically attributed to SL participation rather than the classroom environment, the findings did indicate that students experienced growth in course content overall after participation in SL. Many STEM faculty have been resistant to integrate SL into their courses because of time constraints and the perception that SL lacks rigor, however, this study illustrates that SL has the potential to augment student learning by creating a lab type of environment for application of course concepts to relevant, authentic settings. Given that more than half of freshmen who declared STEM majors at the start of college left these fields before graduation (Chen, 2013; National Girls Collaborative, 2018), it is clear that SL has the potential to augment student learning in STEM. In this study, SL benefitted students across the board and was therefore a valuable tool for engaging non-science majors, who were not only exposed to how scientific issues are addressed in the field, but also increased their scientific literacy about how these issues applied to their local communities. As student agency increased through participation, student course content knowledge also grew, therefore increasing scientific literacy and promoting interest in STEM. This finding is powerful in that it shows that SL has the potential to create an accessible pathway for students for many walks of life to engage in the scientific process and feel they have a role within it.

This study found that incorporating SL into STEM courses had significant benefits to students from a broad range of backgrounds. Given that most students in the course saw gains in course content knowledge and that agency was positively correlated with these gains, SL STEM can provide avenues for students from traditionally underrepresented backgrounds to build social and scientific capital as they work alongside scientific professionals and network with other students and community organizations. In addition, the findings show that SL participation positively impacted student agency overall, which may increase student self-efficacy in science, as they apply course content knowledge to relevant, hands-in settings where they are engaging in meaningful tasks that have positive implications for the larger community where they live. In this course, for example, many students came from non-traditional backgrounds. Several students in the course were part of the federally funded TRIO program that supports low income and first-generation students and the CAMP program (College Assistance Migrant Program), which supports students from migrant farm working backgrounds. Many of these students had the highest agency scores in the course on both the reflection journals and post-service agency survey. Several other students in the course were non-traditional students returning to college after many years or veterans starting college for the first time after years of service in the military. Many of these students talked openly in class about how they enjoyed the SL experience because they were able to apply life and career skills to projects tasks and often took on a leadership role in the projects as a result. If the goal is to increase participation and interest in the STEM fields, then the findings from this study clearly illustrate that value of adding SL to introductory level science courses.

No significant differences in course content knowledge or agency were found across SL project sites in this study. Because of this finding, it is difficult to say whether gains in course content were specifically related to the SL experience, or if they were also influenced by the classroom environment and how content was delivered. However, many student reflection journals did indicate that participation in SL helped them to apply course concepts in relevant and tangible settings. For this reason, it is hypothesized that the content gains were likely attributed to the fact that projects in this course used SL best practices and offered high quality experiences for students that fostered both course content and agency growth. These findings are well-aligned with the findings from other authors in SL STEM that show use of SL best practices and careful alignment of the SL project and course content can lead to major gains in SL even in the STEM fields. This finding does show that for SL STEM to result in increases in course content knowledge and agency, then it must be done thoughtfully with careful attention to course alignment and project design. For example, in this study, the community partners went to great lengths to insure students' success, by adjusting scheduling and communication styles to best meet students' needs. However, if this data had been collected from a new project that was not using best practices, it is possible that significant differences would have been found between projects.

Limitations

There were several limitations of this study that are described below. One of the main limitations of this study was that the researcher was also the instructor for this course. While this gave the instructor more access to the students and a more holistic picture of the SL experiences, that might have also affected the reliability of the study, since this could have clouded the interpretation of the findings.

A second limitation of the study was related to student participation rates. Given that students had the option of not consenting, it is possible that students with the lowest levels of agency did not consent to the research. In addition, some students did not complete both the pre and post content assessment, reflection journal, and agency survey. It is possible, especially given that the reflection journal was a graded assignment, that the students with missing data were students with lower agency students overall.

Another limitation related to student data was the low number of students who completed both the pre and post content assessment. On the day of the post content assessment, the test settings were not set up correctly resulting in some student data not being saved correctly. This lowered the overall number of students who completed both pre and post content assessments to only 44 out of 67 participants and may have impacted the overall results.

Finally, a limitation of this study was that there it was there were last minute changes in project partners due to staffing changes at one of the agencies. One of the most consistent, long-time community partners, dropped out at the last minute, leaving the SL office to scramble to find a suitable, level "one" project for the class. The policy project that replaced the land use project was not well-aligned with the course content and therefore was not able to be included in qualitative analysis.

Recommendations and Conclusions

The results of this study show that incorporating SL into STEM courses, if well-integrated, comprehensive in length and design, and thoughtfully structured to best meet student needs, has the potential to increase both course content knowledge and agency within students. When projects are well-designed and use best practices, SL STEM can provide a bridge between course content and its application to real-life scientific contexts. SL projects provide engaging, hands-on experiences where students can relate scientific concepts to community issues that are relevant to their daily lives and can foster increased interest in science, build scientific literacy, and engage students from a broad spectrum of demographic backgrounds. One of the most critical aspects to building a successful SL STEM project is project design. An SL project must be well-aligned to course content and community partners well-engaged in this process. In addition, student reflection of the SL experience is also critical to this process and students must have the opportunity to engage in the ELT cycle and connect concrete experiences at the SL sites with guided reflection that connects these experiences to their own lives. By doing this, students are more likely to reach the active experimentation part of the ELT cycle, in which they apply SL experiences to their lives and continue to take action and apply this knowledge in the future.

This study shows that SL STEM can have significant benefits to students. However, given that literature in SL STEM is currently limited in scope, and that the N for this study was relatively small, additional research is needed that builds upon the findings of this study. Future studies that are larger in score are needed, as well as research that specifically measures the impacts of SL STEM demographically. In order to design SL projects that best meet the needs of students, it is essential to get a better sense of how SL affects students from different demographic backgrounds. For example, does SL result in higher agency or course content gains in women? Underrepresented groups? Finally, while we know that SL project design is critical to a successful project, future research is needed that covers a range of STEM disciplines and courses in order to gain a broader sense of the overall impacts of SL STEM.

In addition, future studies are needed that more accurately measure how course content knowledge develops at the SL site specifically. Previous studies have had difficulty disentangling course content gains from SL from the classroom environment. To avoid this, the course content prepost test in this study was designed to include questions specifically related to each SL project. However, the findings from research question two found no significant differences across SL projects in student responses to these questions. In this study, where SL was well-integrated into the classroom content, it was difficult to disentangle SL learning from in-class instruction. As a result, it was nearly impossible to assess whether student gains in course content were specifically related to SL participation or to the classroom environment. Future research could more accurately measure course content knowledge growth from SL participation by measuring student content growth in two separate courses, one that included SL and another a control group that did not include an SL component. Other variables, such as the instructor's teaching style and curriculum for the course without SL would have to be carefully controlled.

Another area for future research are studies that more accurately assess how future agency develops. This study measured future agency by asking students about their future plans after completion of the projects. However, to truly measure future agency, a study would need to be longitudinal, with data collected over a much longer timeframe. Studies that follow-up with community partners over several years and assess student return volunteer rates, or studies that follow up with specific students in these courses after graduation would provide a more accurate picture of how future agency is impacted by SL participation. In this class, for example, I spoke with a student from the course the semester following the study. He shared with me that he had applied for an internship position at the land use project he served at because he enjoyed the project tasks and found the SL project to be incredibly meaningful. Although he was a political science student at the time of taking the course, he felt that SL had exposed him to new ideas about conservation and made him re-consider how it impacted his local community and his role within it. The following day, I ran into another student from the course who shared with me that she had recently changed her major to Environmental Studies after taking the class and participating in SL. She explained that the SL experience had exposed her to new ideas about sustainability that she had never considered before and that she wanted to continue to work in this area. When I looked back at these students' responses on the post-service agency survey, however, they both had medium agency scores rather than high. Clearly, it is difficult to assess how SL participation in a one-semester course will impact students, so more long-term studies are needed to provide data on the long-term effects. Being able to run a SL project over multiple semesters with the same student population would be another effective way to measure this more clearly.

This study has shown that overall, SL STEM has potential to engage and motivate students from many walks of life and, if well-designed, has the ability to affect both course content and student agency.

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APPENDIX A

Agency Pre/Post Reflection Journal Questions

Pre-SL Reflection Questions

1. Have you had any previous experience with service-learning or environmental field work? If so, please describe it below.

2. Why did you choose this specific service project? Did any of your previous experiences/interests influence your decision? If so, please describe.

3. In what ways do you think working on this issue will help you understand your course information?

4. What do you expect to learn in your service project?

    a. What impact do you expect to have on the community through your service learning project?

    b. What specific skills do you hope to gain through the service experience?

    c. What specific course content knowledge do you hope to gain through the service experience?

    d. What specific personal development do you hope to gain through the service experience?

5. What role do you imagine yourself taking on in your service learning project?

6. What are you most looking forward to in your service learning project? What are you most concerned about?

Post SL Reflection Questions

1. Describe a highlight of your service experience and any challenges you faced. How did they affect your service experience?

2. What activities did you typically do during your service project? What was your specific role/responsibilities?

3. What was the service environment like? Did you typically work alone or in groups? Describe the typical setting. How often did the community partner work with/communicate with students in the project?

4. How did the service experience relate to class material? How was this information communicated to students? Do you feel it was it effective? Why or why not? Describe specific course topics that linked to your service. Provide a specific example of how a course concept was linked to service.

5. What have you gained through service-learning participation? What specific skills have you developed through service-learning? What specific personal qualities have you developed? How will you apply these skills to your life?

6. Do you feel like you can make a difference with this issue in the future? If so, how? If not, why not? Do you plan to continue to volunteer with this issue in the future? If so, in what capacity?

7. Have your opinions about environmental issues/science changed at all through this service-learning experience? Why or why not?

APPENDIX B

Agency and Course Content Survey Instrument

Agency Pre/Post Questions

1. I have had positive experiences with science in my academic career.
2. I feel that I can be successful in a science course.
3. I feel comfortable dialoguing about scientific/environmental issues as they relate to my local community.
4. Caring for the natural environment is important to me.
5. I feel I have a role in protecting the natural environment.
6. I have an interest in volunteering with environmental issues.
7. Living a sustainable lifestyle is something I value.
8. My major/career interests lie in science or environmental studies

Agency During the SL Project (Post SL-Service Questions only)

1. I feel I have a role in protecting the natural environment.
2. I had significant responsibility in project tasks (ie. took a leadership role)
3. Students were given meaningful tasks to complete at the project
4. The work we did at the project had value and purpose to the community
5. I could relate the work we were doing to my own life
6. I was highly engaged in service-learning project tasks
7. Service learning was a positive experience for me.
8. Participation helped me to see the value of scientific participation in daily life

<u>Agency in the Future (Post SL-Service Questions Only)</u>

9. I plan to continue volunteering in this project after the SL project is done

10. I plan to continue to volunteer in environmental issues in the future

11. I have made lifestyle changes towards sustainability as a result of participation in SL

12. I plan to pursue a major/career in science/environmental issues as a result of SL

13. I feel better prepared to discuss issues related to science and the environment with others as a result of participation

<u>Course Content (Post SL-Service Only)</u>

1. Participating helped me better understand course concepts

2. I have a better understanding of scientific issues as a result of SL participation

APPENDIX C

Course Content Knowledge Pre/Post Test

1. A positive feedback loop:

   A. is when feedback into a system increases a rate of response.

   B. is when feedback into a system decreases a rate of response.

   C. may be seen in some examples of population growth.

   D. is when a system responds to a change by returning it to its original state.

   E. Both A and C

2. What factors are used to classify a biome?

   I. Average temperature

   II. Average precipitation

   III. Distinctive plants adapted to area

   A. I only

   B. II only

   C. III only

   D. I and II

   E. I, II, and III

3. What impact does deforestation have on the carbon cycle?

   A. increase in amount of CO_2 in the atmosphere

   B. decrease in the amount of CO_2 in the atmosphere

   C. increase in the amount of photosynthesis

   D. increase in the amount of cellular respiration performed by autotrophs

   E. deforestation has no impact on the carbon cycle

4. Which of the following are processes in which evolution occurs?

I Artificial selection

II Natural selection

III Genetic drift

A. I only

B. II only

C. III only

D. II and III

E. I, II, and III

5. Developing countries tend to have a(n) ____ age structure diagram.

A. rectangular-shaped

B. inverted triangle

C. pyramid-shaped

D. square

E. round

6. The soil that is best for growing most plants is composed of - AG Projects

A. clay because it retains nutrients and water tightly.

B. sand because water drains most easily.

C. silt, because it is a medium sized particle.

D. a mixture of sand to drain well and clay to hold nutrients.

E. a mixture of sand, silt, and clay that promotes water drainage and retention.

7. The tendency of a shared, limited resource to become depleted because people act out of self- interest for short-term gain is generally referred to as

Answer

A. capitalism.

B. communism.

C. the invisible hand.

D. the tragedy of the commons.

E. the Hardin effect.

8. Which of the following statements about sustainable agriculture is NOT true? - AG Projects

A. Sustainable agriculture is often based on traditional agriculture techniques.

B. A key component of sustainable agriculture is soil protection.

C. Sustainable agriculture is more labor intensive than conventional agriculture, and so cost is an issue in areas with high labor costs.

D. Sustainable agriculture does not use mechanization.

E. Sustainable agriculture uses techniques such as crop rotation, intercropping, and agroforestry to protect soil substrate and nutrients.

9. Which of the following energy sources is considered nonrenewable?

I. Wind

II. Nuclear fuels

III. Fossil fuels

A.I only

B.II only

C.I and II only

D.II and III only

E.I, II, and III

10. The difference between a point source and a nonpoint source of water pollution is that

A. a nonpoint source is easily identifiable.

B. point sources can be targeted for reduction.

C. nonpoint sources tend to be factory outputs.

D. point sources tend to be agricultural in nature.

E. nonpoint sources are less harmful to the environment.

11. When non-local species spread rapidly across large areas, they are called -Land Use Projects

A. alien species.

B. invasive species.

C. exotic species.

D. native species.

E. endangered species.

12. The concentration of which of the following greenhouse gases is LEAST affected by human activity?

A. water vapor

B. carbon dioxide

C. chlorofluorocarbons

D. methane

E. carbon monoxide

13. Which of the following is the best reason why exotic plants such as kudzu are able to grow uncontrollably? - Land Use projects

A. kudzu produces very little nectar to attract insects.

B. chemical defenses are non-existent in kudzu.

C. kudzu has no natural predators in the range it has been introduced.

D. kudzu is camouflaged from herbivores.

E. the plant grows slowly, so herbivores don't bother eating it.

14. When a chemical manufacturing company develops a chemical, extensively tests it, discovers it to be unsafe, and never brings it to market, it is following the

A. precautionary principle.

B. actual-risk probability principle.

C. risk-management principle

D. risk assessment and management principle.

E. innocent-until-proven-guilty principle.

15. Which of the following is NOT one of the top 5 causes of biodiversity loss globally?

A. pollution

B. disease

C. invasive species

D. habitat alteration

E. climate change

16. In order from the most desirable to the least desirable, the 3 R's stand for - Recycling projects

A. recycle, reuse, reduce.

B. recycle, reduce, reuse.

C. reduce, reuse, recycle.

D. reduce, recycle, reuse.

E. reuse, reduce, recycle.

17. The major component of MSW in the United States is - Recycling projects

A. paper.

B. yard trimmings.

C. metal.

D. plastic.

E. wood

18. One of the greatest problems associated with recycling is - Recycling Projects

A. the amount of land required to accommodate the material.

B. recycling has increased MSW generation.

C. people in the United States are not inclined to participate.

D. there is no legislation to promote recycling.

E. there is not always a market for recycled goods.

19. All of the following are causes of increased wildfire activity on public lands EXCEPT - Land Use Projects

A. human negligence

B. increases in bark beetle population

C. increases in invasive species such as cheatgrass outcompeting native species

D. removal of dead trees from public lands in recent years

E. years of fire suppression leaving thick stands of trees

20. benefits to composting include all of the following EXCEPT - AG Projects

A. reduction of organic materials that are sent to landfills

B. reducing anaerobic decomposition and methane gas release from landfills

C. reduction of dairy and meat products that are sent to the landfills

D. improving soil fertility in agricultural fields

E. prevention of soil erosion

21. which of the following would NOT be categorized as e-waste?

A. CRTs

B. computers

C. cell phones

D. construction debris

E. portable music players

22. When conducting a life-cycle analysis of manufactured goods which of the following would NOT be considered?

A. the amount of raw material required

B. the amount of energy needed to transport the material

C. the amount of money the end product will cost

D. the chemicals used in the manufacture of the goods

E. the disposal of the product

23. Which of the following is the most significant contributor to the modern “throw-away society”?

A. landfill technology

B. labor saving appliances

C. transmission lines that provided electricity to the majority of homes

D. planned obsolescence

E. disposable income in developing countries

24. An environmental cost of sending computers to landfills is that

A. there is inadequate landfill space in the United States for computers.

B. it is less expensive to send computers to the landfill than to recycle them.

C. children separate the components of the disposed of computers.

D. the disposed computers contain toxic metals that can end up in the environment.

E. landfill standards keep the toxic compounds in the computers from leaching into the water table.

25. Which of the following best explains why the recycling of plastic is an example of open-loop recycling

A. manufacturers may use a lesser amount of material for newer products.

B. plastic bottles can be melted down and then used in the production of new bottles.

C. plastic bottles can be recycled and used in the production of different plastic products.

D. recycling plastic reduces the need for the raw material.

E. plastic products can be used repeatedly before disposal

26. Zero waste is a philosophy that encourages the redesign of resource life cycles so that all products are:

A. incinerated

B. reused or repurposed

C. recycled

D. produced locally

E. open-loop recycled

27. The material rotating in the North Pacific Gyre can best be described as

A. microplastic solid waste

B. organic waste dumped from cruise ships.

C. medical waste dumped by the United States.

D. coal slag dumped by China.

E. larger plastic solid waste

28. Public lands in the United States are categorized for use based on the managing agency. In general, Bureau of Land Management (BLM) lands are used for

A. grazing, mining, timber harvesting, and recreation.

B. timber harvesting, grazing, and recreation.

C. recreation and conservation.

D. wildlife conservation, hunting, and recreation.

E. primarily preservation.

29. After a forested area such as a national forest is clear-cut or burned by wildfire, what type of succession occurs?

A. primary

B. secondary

C. pioneer

D. climax

E. biome

30. What is most significant when determining the diversity of an ecosystem?

A. the total number of organisms present

B. the number of different species present

C. the amount of land the ecosystem covers

D. the amount of precipitation an ecosystem receives

E. the interactions between producers and consumers

31. Sagebrush is often considered a keystone species in the grassland/cold desert biome because of all of the following EXCEPT:

A. It provides coverage and security from predators for many wildlife species such as the sage grouse.

B. it provides forage for many animals in the ecosystem

C. it is a highly digestible food source

D. it increases the frequency of wildfires

E. it's removal leads to an increase in the presence of invasive species such as cheatgrass.

32. Roles of state wildlife management agencies such Fish and Game include all of the following EXCEPT:

A. manage road kills reports

B. education of the public

C. create management plans for plants

D. restore forage habitats following disturbance such as wildfires

E. regulate and enforce hunting, fishing, and poaching

33. Fire intensity has increased on the sagebrush steppe ecosystem has increased due to all of the following EXCEPT:

Loss of native sagebrush habitat

Decline in number of native wildlife species such as the sage grouse

Increased recreation on public lands

Fire cycle of cheatgrass relative to sagebrush

Increased presence of invasive species

34. Characteristics of the grassland/cold desert biome include which of the following:

Gross primary productivity and net primary productivity levels are similar

Moderate to high precipitation levels

High net primary productivity

Plant species adapted to extreme drought

Hot summers and cold winters

35. Monocropping has a number of disadvantages. These include all of the following EXCEPT:

A. erosion due to exposure of large areas of soil during planting.

B. nutrition and pesticide application needs are generally similar throughout a single crop.

C. pests are more likely to attack a monocrop due to the high concentration.

D. loss of habitat for natural pest predators.

E. reduction of productivity due to loss of nutrient-rich topsoil.

36. Industrial Agriculture has many benefits. Which of the following is NOT a benefit associated with industrial agriculture?

A. protection of the soil.

B. there is larger food production per hectare.

C. monoculture can be more efficient.

D. economy of scale can make the food less expensive.

E. none of the above

37. The function(s) of soil is/are the following:

A. filter of water and atmospheric chemical compounds.

B. habitat for organisms.

C. anchor for plants.

D. location for recycling of organic matter.

E. all of the above

38. The use of synthetic fertilizers increases crop yields but also

A. destroys the nitrifying bacteria in the soil

B. increases fish populations in nearby streams

C. decreases phosphorous concentrations in the atmosphere.

D. increases nutrient runoff into bordering surface waters.

E. slows the release of organic nutrients from compost.

39. Which pollutant or pollutants are most likely to create eutrophic areas, for example as seen in the Snake River?

A. nitrates and phosphates

B. synthetic organic compounds

C. heavy metals

D. solid waste

E. pharmaceuticals

40. Which of the following lists of agricultural irrigation techniques is in the correct order, from least efficient to most efficient

A. drip irrigation, furrow irrigation, flood irrigation, spray irrigation

B. spray irrigation, furrow irrigation, flood irrigation, drip irrigation

C. furrow irrigation, flood irrigation, spray irrigation, drip irrigation

D. furrow irrigation, spray irrigation, drip irrigation, flood irrigation

E. furrow irrigation, flood irrigation, drip irrigation, spray irrigation

41. Integrated pest management (IPM), often used in sustainable agriculture, is likely to use all of the following techniques EXCEPT

A. crop rotation

B. intercropping

C. planting herbicide resistant crops

D. habitat creation for pest predators

E. increased use of traditional pesticides

APPENDIX D

Community Partner Interview Protocol

1. What is your organization’s mission or purpose? What is the community issue students are addressing with their service? What is the depth and scope of your service-learning project (ie hours, days, etc.)?
2. What are the typical tasks/responsibilities that students take on during their service? Describe some specific examples of how students engaged with the community issue you are addressing.
3. Can you describe the types of roles students took on during the project, both typical and atypical? Are their opportunities for students with experience to take on more responsibility?
4. During the project, how closely do the students work with the agency staff or other volunteers? (ie do students typically work alone, in teams, or with other staff?) How do they typically receive feedback/instructions?
5. What scientific/environmental topics are covered in the project? How are these typically communicated with the students? Can you provide a specific example of a topic and how it it covered? Did students ever apply class topics to address the community issue? If so, can you share an example?
6. In general, how would you describe the level of commitment/engagement by students participating in your project? How would you describe a highly motivated/engaged student versus a student with low-level of motivation/engagement? What factors do you think might contribute to engagement level?

7. After the project is complete, what are some ways that students can stay involved with this issue? Have students expressed interest in staying involved? Have you seen any return volunteers?

APPENDIX E

Course Syllabus

INTRODUCTION TO ENVIRONMENTAL STUDIES (ENVSTD 121)

Fall 2018, Tues/Thurs 10:30 – 11:45

Instructor: Mari Rice, M.S. Environmental Studies, Doctoral Candidate, Ed.D

E-mail address: maririce@boisestate.edu

Office hours: Tuesday 2-4pm, Environmental Research Building (ERB) 2139 or by appointment. Please email me or speak to me if you wish to set-up an appointment.

Course Objectives:

Introduction to Environmental Studies explores the various processes that contribute to the functioning of the environment as well as the ways people interact with and impact it. The goal of the course is to provide a knowledge base that can be used to understand the interrelationships of the environment and to identify, analyze, and evaluate environmental issues. Although Environmental Studies incorporates a wide set of topics, there are several unifying themes. The following core concepts provide a foundation for the course:

1) Environmental Studies combines the application of knowledge from the natural and social sciences and humanities
2) Science is a method of learning about the world
3) Ecological processes are based on energy conversions that flow through parts of an

   environmental system

4) The environment is interconnected and changes over time and space
5) Humans have been part of nature for millions of years, but the impact of humans on the environment has increased (in rate and scale) with changes in technology, population
growth, and continued use of fossil fuels
6) Knowledge and critical thinking skills used in a scientific and informed approach can be applied to meaningful decisions about real-world environmental issues and community engagement

Course Outcomes

ENVSTD 121 satisfies 3 credits of the Foundational Studies Program's Disciplinary Lens - Natural, Physical and Applied Science requirements (DLN). The University Learning Outcomes developed in this course include:

ULO 8: Apply knowledge and methods characteristic of scientific inquiry to think critically about and solve theoretical and practical problems about physical structures and processes.

ENVSTD 121 is designed to provide an introduction to the concepts and issues of Environmental Studies, as well as the scientific process. It explores interdisciplinary topics linking science and technology with humans and the environment. It integrates scientific, sociopolitical, and humanistic approaches to the understanding of ecosystems and how humans interact with the natural world. The course examines real-world environmental issues and demonstrates how the scientific method and an integrative, interdisciplinary approach are used to formulate questions and test observations. After successful completion of this course, you will be able to:

1) Effectively communicate about scientific findings and environmental issues
2) Use knowledge and methods based on the scientific process to evaluate and analyze

   information and propose solutions to environmental issues
3) Develop research questions to examine environmental issues
4) Identify the variety of natural resources used by humans
5) Evaluate the role human activities have on environmental pollution, biodiversity, and

   global change
6) Apply an interdisciplinary perspective to make meaningful economic, ethical-value,

   public policy choices and decisions in the context of environmental topics
7) Apply course concepts to environmental issues facing our region through hands-on service learning experiences at local agencies

Content and Textbook

There are three parts to the course. We will begin with an overview of environmental studies and science (Part 1), then discuss natural resources and challenges of resource management (Part 2), and end with an overview of human impacts on the environment and a framework for solutions and paths towards sustainability (Part 3). These topics will be covered using a text available in hardcopy or as an e-book

(*Essentials of Environmental Science* by A. Friedland et al. - either edition of the book is fine), along with in-class presentations using PowerPoint, selected readings, videos and Internet resources.

2 copies of the textbook are on reserve at Albertsons Library.

Academic Dishonesty:

Any form of academic dishonesty is a strict violation of University policy. A student caught cheating, plagiarizing, or participating in any activity deemed by the instructor as a violation of academic dishonesty rules (see Student Code of Conduct Article 4 section 1) will be reported to the Office of Student Rights and Responsibilities, sanctioned, and may be subject to further action by the University (see Student Code of Conduct Article 6 sections 1- 2). **You are required to cite all sources used on assignments**. A copy of the Student Code of Conduct is available online at: http://osrr.boisestate.edu/scp-codeofconduct/

Disabilities Statement:

Students with disabilities needing accommodations to fully participate in this class should contact the Educational Access Center (EAC). All accommodations must be approved through the EAC prior to being implemented. To learn more about the accommodation process, visit the EAC's website at https://eac.boisestate.edu/new-eac-students/.

Blackboard Site

We will use the course blackboard site in this course for announcements, quizzes, course documents, discussion board posts, and assignments. Class powerpoints, syllabus, rubrics, and course readings are found under the "Course Documents" tab.

Class Environment/Policies

There are a number of grading requirements for this course. I will post a weekly checklist each week on blackboard to remind you of assignments and deadlines. You are expected to participate with regular class attendance. Come prepared for class, be on time, complete the assignments on schedule, be respectful, and set high standards for your work. Please read the assigned chapter before the start of class that week. No credit will be given for late papers or other learning activities. Please speak with me ahead of time if you have a conflict regarding a due date – I can usually accommodate proactive students.

Electronic Device Policy

We will occasionally use electronic devices for class activities and to save paper. However, **use of cell phones/laptops for things unrelated to class material during the class will result in a loss of participation points for that day**. **Please be respectful of the class environment and this policy.**

Attendance Policy

If you have more than 4 unexcused absences, your grade will be dropped 1 letter grade. Please email me ahead of time if you will not be able to attend class for reasons such as illness, emergencies, etc. Please provide paperwork to excuse any absences (doctors note, travel authorization, work, etc).

Evaluation

There are a number of grading requirements for this course that are outlined below:

Evaluation Criteria	**Percentage**
Exams	33% (11% per exam)
Chapter Quizzes	13%
Homework/Discussion Board	10%
Class Participation	12%
Civic Engagement Project	15%
Group Presentation	7%
Final Paper	10%
Total	100%

Exams (33%)

These are ***non-cumulative*** and multiple-choice/fill-in the blank exams that are taken at the Online Testing Center (SMASH E213). Exams are based on the material covered in the textbooks and in class. You need to schedule a time to take your exams. Sign up for the exams as soon as possible at: https://testing.boisestate.edu

***For the first two exams, there will be NO CLASS on the day of the exam.**

Exam 1 (11%): September 19th and 20th

Exam 2 (11%): October 23rd and 24th and 25th

Exam 3 (11%): December 10-14th (Finals week)

Chapter Quizzes (13%)

These are *repeatable, open book* quizzes based on the information provided in each chapter. You may take each quiz a total of **3 times**. Quizzes will be accessed on the course blackboard site. They are designed as a way for you to review the material in the chapter in order to better prepare you for the exams. **Quizzes are weekly. Each chapter quiz is ONLY open the week we are studying that chapter. Please review the class schedule for due dates!** Your lowest quiz grade will be thrown out at the end of the semester.

Class Participation (12%)

This course is highly interactive and class participation is an integral part of the course. Class participation will involve various learning activities. These activities will count towards your participation in class. We will also have 2-3 in-class quizzes throughout the semester. Please note that you **must attend class to get credit for a class participation activity.** If you are using your cell phone or laptop for reasons not related to class, you will lose your participation points for that day. If you leave early without checking in you will also NOT receive full credit.

Homework Assignments/Discussion Board (10%)

About every other week, there will be a required homework assignment or discussion board post due. Assignments will be posted each week on Blackboard and announced in class. Each assignment will be graded. All homework must be submitted in-person or on the blackboard course site at the beginning or prior to the class that it’s due or you will be given a zero for that assignment.

Service Learning Project (15%)

Service Learning is a requirement of the course. You will complete 15 hours of hands-on field experience at a local environmental agency. Activities range from sagebrush planting and trail building to gardening and watershed education. The purpose of service learning project is to allow students to develop practical knowledge about local environmental issues, network with local agencies and non-profit organizations, and translate academic skills into real world applications. There are three possible ways to complete the civic engagement project:

1) Completion of 15 hours of Service Learning with a local environmental agency.

   To register for a Service-Learning project you will receive an email with instructions from the Service-Learning Program to join Org Sync. If you do not receive this email by 8/24 please let me know. Students need to register for a Service Learning project by **August 31st**. You will record all your hours in OrgSync and this must be completed by **December 14th**.

2) Completion of a student-initiated, course-related, and instructor approved project at a local environmental organization. If you are interested in option 2, please speak with me directly. You will complete the student initiated project form at: http://servicelearning.boisestate.edu/about/forms/ and return it to me by **September 6th**.

3) Completion of a comprehensive (10-15 page) environmental issue/policy research paper on a course-related topic approved by the instructor. The paper must center

on a student designed research question, use an instructor approved experimental design for data collection and analysis, and report a summary of findings. **Paper Outline DUE September 13th!**

* For options 2 and 3, students must speak to and be approved by instructor by **September 6th**.

Your service experience will be graded based upon completion of the following:

- Completion of Hours and Orientation (documented via OrgSync)

  65%

- Completion of pre and post service learning journal on BB

  10%

- Participate in In-Class Poster Making Session

  10%

- Complete and Present Reflection Poster

  15%

Class Presentation on Local Environmental Issues (7%)

Small groups will present a powerpoint presentation to the class on a topic specific to Idaho with discussion questions. Topics are listed on the course schedule. More specific detailed information, group assignments, and rubric will be given later.

Final Project: Infographic/Research Questions (10%)

You will complete a comprehensive final paper that ties together the topics we have covered in this course as they relate to environmental sustainability. Specific details and rubric for this assignment will be given at a later date.

Extra Credit

Extra credit will be offered throughout the semester for attending guest speakers, etc. I will post extra credit opportunities as they arise on blackboard announcements.

Grading Grades for the course will be **weighted** and based on total percentage earned. The following grading scale will be used as the basis for determining your final grade:

100-97%	A+
96-93%	A
92–90%	A-
89-88%	B+
87-83%	B
82-80%	B-
79-78%	C+
77-73%	C
72-70%	C-
69-68%	D+
67-63%	D
62-60%	D-
Below 60%	F

ENVSTD 121 Class Schedule Fall 2018

WK	***DATE***	***TOPIC***	***SERVICE LEARNING (SL)***	***READING, DUE DATES***
Section 1: Environmental Studies and Environmental Science				
1	8/21	Introduction to Environmental Science, Syllabus, Introductions		Chapter 1, Essentials of Environmental Science, Friedland et
	8/23	Introduction to Service Learning Component	*SL Overview, Agency*	Chapter 1, Freidland et al.
2	8/28	Matter, Energy, Change Scientific Method		Chapter 2, Friedland et al.
	8/30	Matter, Energy, Change Review	***Select Agency on Org***	Chapter 3, Friedland et al.
3	9/4	Ecosystem Ecology/Biomes	*Attend Agency Orientation (9/3 – 9/14)*	Chapter 3, Friedland et al.
	9/6	Evolution, Biodiversity, and Community Ecology	***Last DAY to Opt Out of SL***	Chapter 4, Friedland et al.
4	9/11	Evolution, Biodiversity, and Community Ecology		Chapter 4, Friedland et al.
	9/13	Human Population Growth *Review Presentation*	***SL Opt-out paper outline DUE***	Chapter 5, Friedland et al.
5	9/18	Human Population Growth *Exam Review*		Chapter 5, Friedland et al.

	9/20	**NO CLASS – Exam 1 (Chpts. 1-5)** **9/19– 9/20 at testing**		
Section 2: Natural Resources				
6	9/25	Land Resources: Tragedy of the Commons, Public Lands, Mining		Chapter 6, Friedland et al. Chapter 7, Friedland et al.
	9/27	Campus Sustainability Tour		Ch. 6 & 7, Friedland et al.
7	10/2	Land Resources: Agriculture and Soils		Chapter 7, Friedland et al.
	10/4	Land Resources: Urban Landscape		Chapter 7, Friedland et al.
8	10/9	Energy ***Presentation 4: Idaho***		Chapter 8, Friedland et al.
	10/11	Water Resources ***Presentation65: Water***		Chapter 8, Friedland et al.
9	10/16	Energy Guest Speaker: Idaho		Chapter 9, Friedland et al.
	10/18	Water Pollution/Oceans *Exam Review*		Chapter 9, Friedland et al.

10	10/23	Solid Waste Generation and Disposal		Chapter 11, Friedland et al.
Section 3: Human Impacts and Solutions				
	10/25	**EXAM 2 (Chapters 6-9)** **Available: 10/23 – 10/25** **NO CLASS**		Chapter 11, Friedland et al.
11	10/30	Solid Waste Generation and Disposal: Toxics *Review Final Infographic Project*		Chapter 11, Friedland et al. **The Clean Bin Project DB DUE**
	11/1	Human Health Risk and Environmental Justice		Chapter 12, Friedland et al.
12	11/6	Conservation of Biodiversity		Chapter 13, Friedland et al.
	11/8	Conservation of Biodiversity		Chapter 13, Friedland et al.
13	11/13	**Service Learning In-Class Reflection: Create Posters**	***SL Reflection In-***	
	11/15	**Service Learning Poster Voting** ***Poster Session***	***Service Learning Poster DUE***	**Posters DUE Tuesday 11/14 at Midnight**
Fall Break 11/17 – 11/25				
14	11/27	Climate Change and Global Warming		Chapter 14, Friedland et al. **Ch. 14 quiz**
	11/29	Climate Change and Global Warming	***SL Post-Reflection Journal***	Chapter 14, Friedland et al.

15	12/4	Sustainability/Infographics ***Presentation 9: Green***		**Final Infographic Project Due In-class**
	12/6	Sustainability/Course-wrap-up	***Service Learning Hours Due 12/7***	Why Bother? By Michael Pollan
16	12/10 – 12/14	**EXAM 3: December 10 – 14th**		Complete Course Evaluation